Moonlight and Wheeler Fires
Recovery and Restoration Project
Forest Vegetation, Fuels, Fire, and Air Quality Report

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1. Introduction

In July 2007, a series of lightning strikes ignited the Wheeler, Davis, and Babcock Peak fires. These fires grew together creating the Antelope Complex Fires which burned approximately 23,000 acres, over 13,000 acres of which burned with high fire severity resulting in greater than 75 percent basal area mortality. In August of 2007, the Moonlight Fire burned over 65,000 acres with over 40,000 acres burning under high severity. These fires burned most of the areas planned for treatment under the Diamond Vegetation Management Draft Environmental Impact Statement (2006). Consequently, these fires have converted a landscape consisting of extensively forested stands into a landscape characterized by vast areas of standing dead trees.

2. Affected Environment

Prior to the Moonlight and Wheeler Fires, the landscape in the project area consisted primarily of pine-dominated Sierra mixed conifer forests, true fir forests, and plantations established over the last 40 years in burned areas and clear-cut units. The project area ranges from 4,000 feet to 7,700 feet in elevation. These forests are within the transition zone—an ecological zone used to describe the transition between the wet productive westside forests of the Sierra Nevada and the relatively dry, less productive eastside forests of the Sierra Nevada. The Moonlight and Wheeler Fires Recovery and Restoration Project area lies on the cusp of the eastern edge of the transition and eastside ecological zones (HFQLG FSEIS, USDA 1999), and consequently, forests in the project area tend to be drier and occur on less productive sites characterized by less developed soils. The Forest Survey Site Class (FSSC) in the burned area ranges from 5 to 7 (based on an index where FSSC 7 represents the least productive site class). Table 2.1 displays the acres within the burned area by Forest Survey Site Class and the equivalent Region 5 site class used for forest vegetation.

Table 2.1 Forest Survey Site Class and equivalent Region 5 site class

Forest Productivity Site Class	5		6	7		
Region 5 Site Class	III	IV	V		N/A	Total
Acres in burned area	13819		64041	8958	177	87647

2.1 *Pre-fire Conditions*

A thorough description of the pre-fire conditions within the project area is described in the Affected Environment section for forest vegetation, fire, fuels, and air quality in the Diamond Vegetation Management Project Draft Environmental Impact Statement (2006).

As with many areas in the Sierra Nevada, the landscape has been heavily influenced over the last 150 years by past management activities that include mining, grazing, harvesting, fire exclusion, large high-severity fires, and more recent drought-related mortality during the late 1980's and early 1990's. At the stand level, the combination of past management activities, fire exclusion, and extensive drought related mortality had created relatively homogeneous areas typified by small trees existing at high densities (Oliver et al. 1996). These high stand densities and high fuel loads created by density dependent and drought related mortality created overstocked stands with high accumulations of ladder fuels and canopy fuels. The combination of these factors increases the potential for stand-replacing high-severity fire events which were unfortunately realized in July and September 2007 when the Antelope Complex and Moonlight fires burned across the landscape.

2.2 Post-fire Conditions

Post-fire conditions were assessed through remote sensing, field observations, and stand exams. The fire severity of each fire was mapped utilitizing Landsat TM satellite imagery and RdNBR classification (Miller et al. 2008, Miller 2007, Miller and Thode 2007, Safford et al. 2007). As described in the pre-wildfire conditions (section 2.1), the areas burned by the Moonlight and Antelope Complex fires were prone to burning under high severity, and did so during these fire events. Together, the Moonlight and Antelope Complex fires burned a over 87,000 acres, with over 54,000 acres (62 percent) of the total area burning under what is classified as high severity (table 2.2) (Safford et al. 2007; Miller 2007). Areas which burned with low severity typically consumed up to 90 percent of existing surface fuels with the majority of trees killed in the less than 10” DBH size class; the majority of trees greater than 20” DBH have signs of needle scorch, but are still alive. Within the moderate severity size class, large pockets, several acres in size are completely killed with some larger trees in the overstory being completely scorched and now dead. Within the high severity class, up to 100 percent of all trees are dead, showing extensive signs of bark char and with most not having any foliage. Due to high consumption of existing surface fuels and a lack of scorch needle foliage, surface fuels and associated ground cover in high severity burn areas is low to non-existent.

Table 2.2 Acres by fire severity class for lands within the perimeter of the Moonlight and Antelope Complex fires.

	Unclassified due to Satellite Imagery [1]	Low Severity	Moderate Severity		High Severity	Total for all severity classes
		BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total within Analysis Area	258	16679	8401	7770	54539	87647
Percent of Analysis Area	0.3%	19%	10%	9%	62%	100%
Total on Private Land	258	3078	1418	1240	13245	19238
Percent of Private Land	1%	16%	7%	6%	69%	100%
Total on Public Land	0	13600	6983	6531	41294	68408
Percent of Public Land	0%	20%	10%	10%	60%	100%

[1] Unclassified area is within private lands on the Northwest portion of the Moonlight Fire (See figure 2.1) . This area was unclassified as it was off the edge of the satellite imagery.

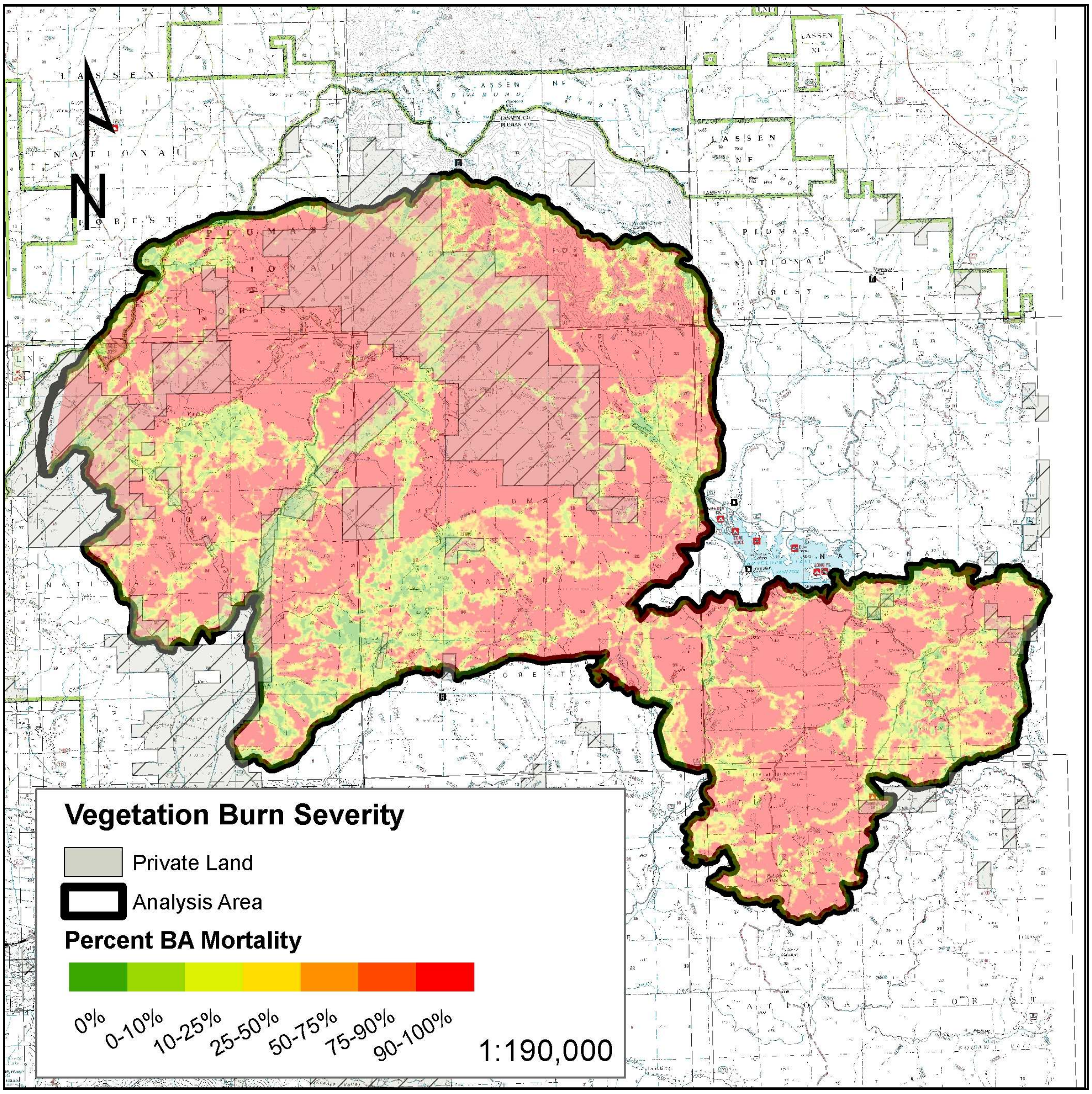
While Odion and Hanson (2006, 2008) argue that “current patterns indicate that low and moderate severity fire are, overall, predominant in contemporary fires” (Hanson Comment Letter 2009), other research described below suggest that these fires burned with very high proportions of high severity.

In this particular project, our concern is with the sum of effects of extraordinarily destructive fires that occurred in the project area. Concerning high severity patch sizes, recent large wildfires are very different from presettlement fires with respect to the average sizes of patches of high severity fire within the fire perimeter. High severity patches more than a few acres in size were unusual in fires in the Sierra Nevada before Euroamerican settlement (Show and Kotok 1924, Kilgore 1973, Stephenson et al 1991, Weatherspoon et al. 1992, Skinner 1995, Skinner and Chang 1996, Weatherspoon and Skinner 1996, Safford 2007, Safford pers. comm. 2008a, Safford 2008b). Miller et al. (2008) have also shown trends indicating that the average size of high severity patches in Sierra Nevada wildfires has increased (by about 100%) over the last 25 years (Safford pers. comm.. 2008a, Safford 2008b).

In the Moonlight and Antelope Complex fires, over 54,000 acres or 62 percent of the total area burned under high severity. This is equivalent to over 85 square miles that burned under high severity within a three month period resulting in 75 to100 percent basal area mortality of forest vegetation. While the occurrence of fire (including low, moderate, and high severity fire) on the landscape is a natural disturbance that is essential to ecosystem function, the large scale of these fires, particularly the vast proportion that burned under high severity, are well outside the natural range of variability in fire size and severity experienced on the Plumas National Forest in the past and are uncharacteristic of the “natural” fire regimes typically described for the dry Sierra Nevada forests (Peterson et al 2009, Miller 2008, Safford 2007, Safford et al. 2007, Safford 2008b, Stephens et al 2007, Beaty and Taylor 2007, Moody and Stephens 2002, , Gruell 2001, McKelvey et al. 1996, Weatherspoon 1996, Weatherspoon and Skinner 1996, Skinner and Chang 1996, McKelvey and Johnston 1992, Leiberg 1902,).

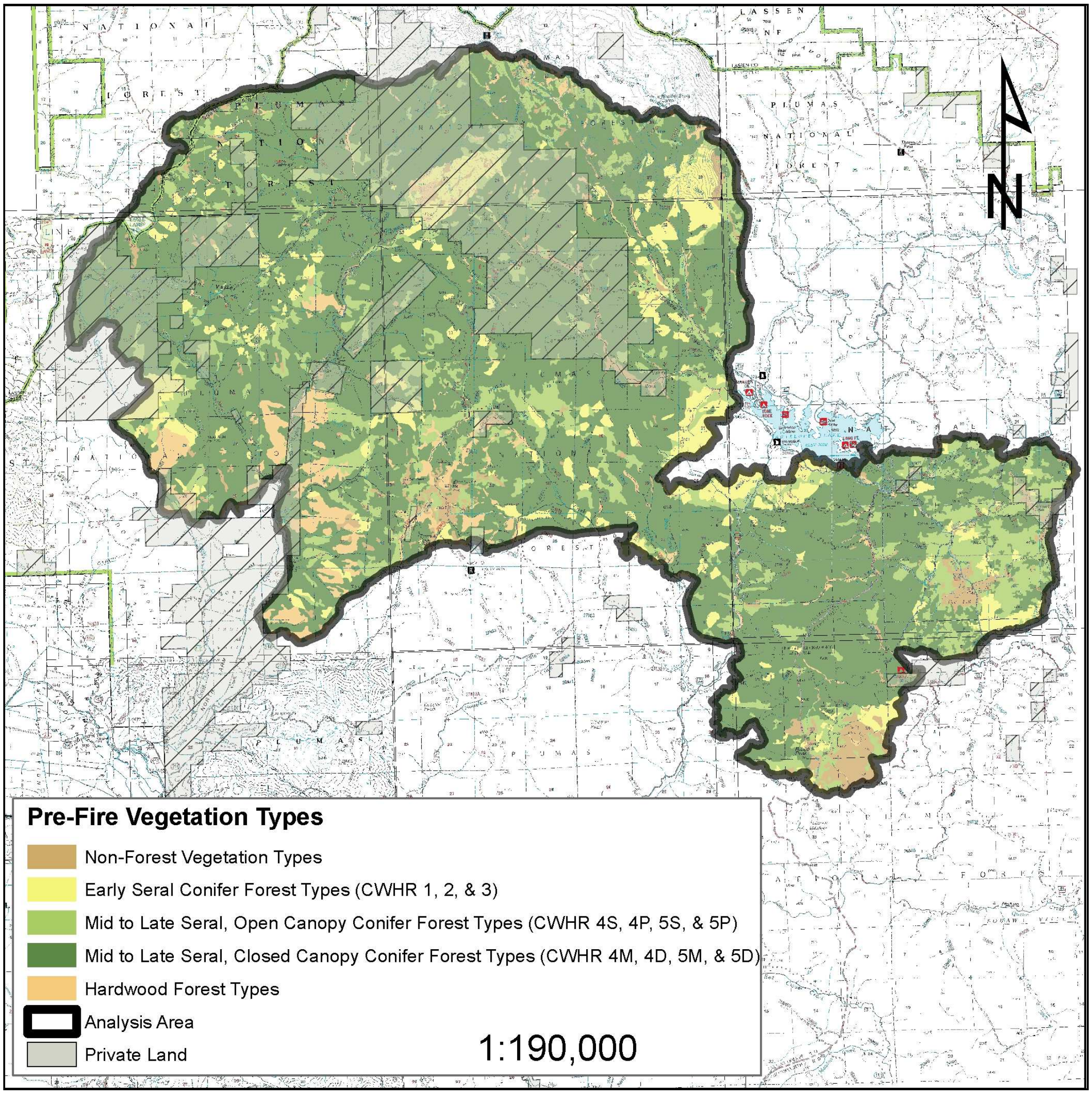
In addition, both the spatial and temporal proximity and adjacency of these two fires and similar severity effects has had a major effect on this landscape. Figure 2.1 displays the fire extent and severity across the landscape.

Figure 2.1 Fire severity for the Moonlight and Antelope Complex fires



The effects of the fire resulted in drastically changing forest vegetation type, structure, and density within the burned area. California Wildlife Habitat Relationship (CWHR) (Mayer and Laudenslayer 1988) typing is used to examine changes in forest vegetation as it classifies vegetation by vegetation type, size, and density. Figure 2.2 displays the vegetation types within the analysis area before the Moonlight and Antelope Complex Fires of 2007. Conifer forest types include Ponderosa Pine, Sierra Mixed Conifer, White fir, Red fir, Eastside Pine, and Lodgepole Pine forest vegetation. Hardwood forest types include Aspen, Montane Hardwood, Montane Hardwood Conifer, and Montane Riparian vegetation. Non-forest vegetation types include Montane Chaparral, Wet Meadow, Perrenial Grassland, and Sage brush types, as well as water and rock substrate types.

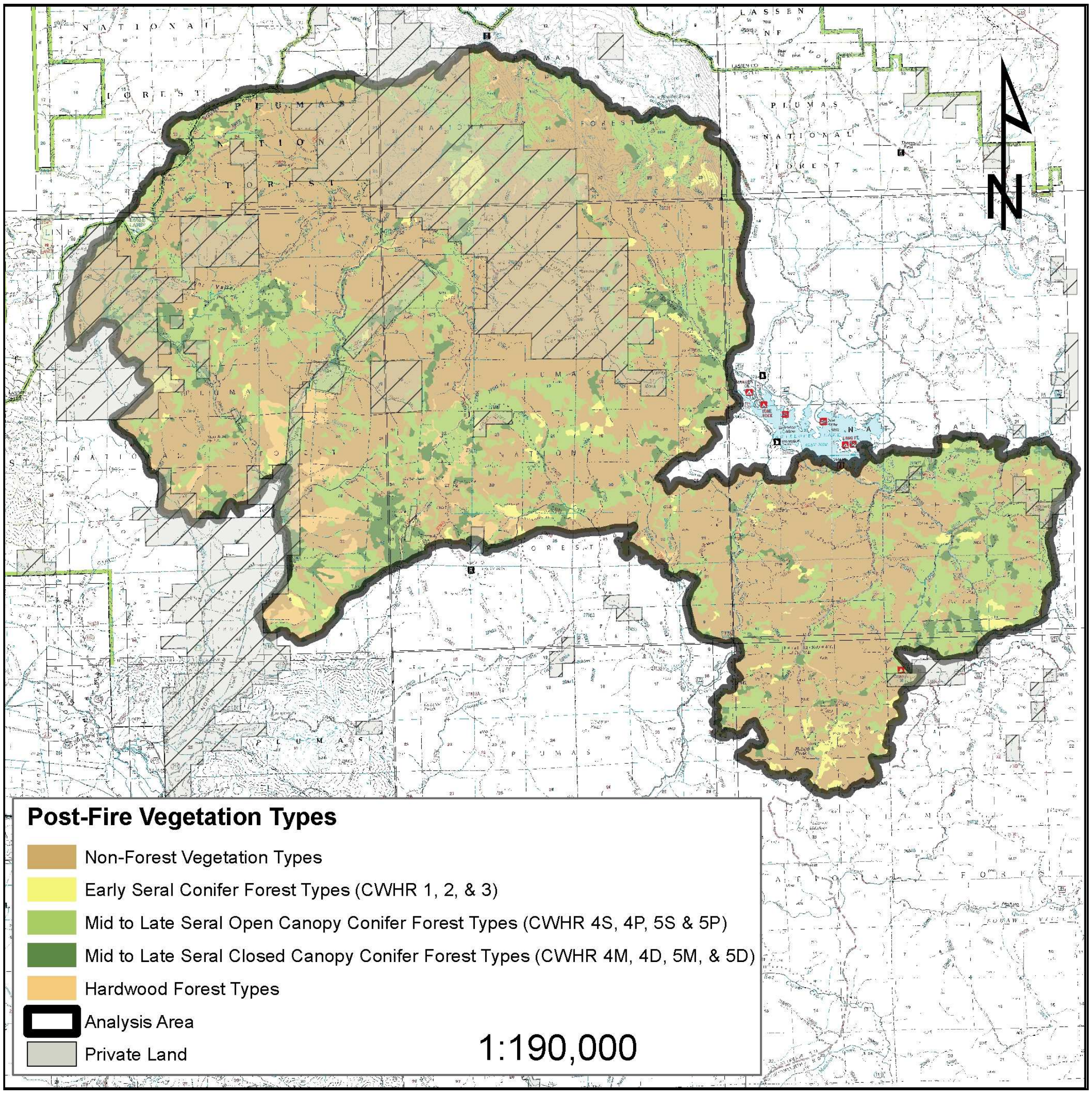
Figure 2.2 Vegetation types within the analysis area before the Moonlight and Antelope Complex fires.



As shown in figure 2.2, the majority of the analysis area was dominated by mid to later seral, closed canopy conifer forests characterized by CWHR 4M, 4D, 5M and 5D size classes and densities. Earlier seral conifer forest types were present, particularly within the footprints of old fires such as the Stream fire (2001) southwest of Antelope Lake, the Elephant fire (1981) at the southern tip of the Antelope Complex fire, the Big Burn (1972) on Wildcat ridge, and the Morton Creek Fire (1959) near the headwaters of Lights Creek.

Figure 2.3 displays the vegetation types within the analysis area after the Moonlight and Antelope Complex Fires of 2007. Note the effect of the fires caused a large scale vegetation type change from mid to late seral closed canopy forested conditions to non-forest vegetation types which is expected to be dominated by brush.

Figure 2.3 Vegetation types within the analysis area after the Moonlight and Antelope Complex fires.



A large majority of CWHR 4 and 5 stands in conifer forest types were converted to non-forest vegetation types as a direct result of the fires. Of these post-fire non-forest vegetation types, over 95 percent (52,000 acres) are expected to be dominated by brush such as Ceanothus and manzanita species. In addition, early seral forest conditions characterized by CWHR size classes 1, 2, and 3 were also converted to non-forest vegetation types (brushfields) due to high mortality in young trees and vigorous post-fire basal sprouting of brush species which can rapidly colonize the site effectively out-competing natural regeneration. Table 2.3 displays the change in acres by CWHR type as a result of the fire.

Table 2.3 Pre and Post fire vegetation as classified by CWHR.

Forest Type	CWHR Size Class	CWHR Density	Pre-Fire Acres	Pre-Fire Percent of Acres	Post-Fire Acres	Post-Fire Percent of Acres	Percent Change
Conifer Forest Types	**1**	**Total**	**63**	**0.1%**	**62**	**0.1%**	-1%
	2	**Total**	**3279**	**3.7%**	**540**	**0.6%**	-84%
	3	**Total**	**3824**	**4.4%**	**1538**	**1.8%**	-60%
	4	D	3282	3.7%	383	0.4%	-88%
		M	36620	41.8%	3861	4.4%	-89%
		P	9525	10.9%	15767	18.0%	66%
		S	2045	2.3%	6537	7.5%	220%
		Total	**51471**	**58.7%**	**26548**	**30.3%**	-48%
	5	D	3858	4.4%	110	0.1%	-97%
		M	16809	19.2%	519	0.6%	-97%
		P	1225	1.4%	557	0.6%	-55%
		S	153	0.2%	288	0.3%	88%
		Total	**22044**	**25.2%**	**1474**	**1.7%**	-93%
Hardwood Forest Types		**Total**	**3604**	**4.1%**	**2603**	**3.0%**	-28%
Non-Forest Types		**Total**	**3361**	**3.8%**	**54883**	**62.6%**	1533%

Table 2.4 displays existing post-fire stand conditions within primarily CWHR 4 and 5 stands in conifer forest types contained by the proposed treatment units. The treatment units were designed to encompass large areas of high severity where the vast majority, if not all, trees within the stands are dead and economic recovery treatments are appropriate. The existing condition in these units and in areas of low and moderate severity where treatments are not proposed are quantified by the data in table 2.4.

Table 2.4 Average existing stand conditions by severity and site class within the burned area.

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Live Basal Area
	Total	0-10"	10-16"	16-30"	>30"	Total	0-10"	10-16"	16-30"	>30"	
High to Moderate Severity Conditions (> 50% BA Mortality); Region 5 sites III & IV											
Existing	11.6	2.1	4.1	3.8	1.0	434.7	354.1	40.9	32.9	5.7	23
High to Moderate Severity Conditions (> 50% BA Mortality); Region 5 site V											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Low to Moderate Severity Conditions (< 50% BA mortality); Region 5 sites III & IV											
Existing	84.1	0.0	40.9	34.7	8.4	42.6	33.3	5.2	1.4	2.6	213
Low to Moderate Severity Conditions (< 50% BA mortality); Region 5 site V											
Existing	96.7	40.0	40.7	12.1	4.0	187.4	180.0	4.3	2.4	0.6	94

The average stand conditions displayed in table 2.4 shows the relative amounts of live and dead trees per acre by diameter class for stands that burned under different severities. In areas that burned under high to moderate burn severity (areas with greater than 50 percent basal area mortality), the high numbers of dead trees relative to live trees underscores high levels of mortality that exist within these areas. Subsequently, these are the areas where proposed action alternatives focus economic recovery treatments. In low to moderate burn severity (areas with less than 50 percent basal area mortality), tree survival, particularly in codominant and dominant overstory trees (10 inches in diameter and greater), underscores that forest vegetation remains and, consequently, green trees or low to moderate fire severity areas are not targeted for removal or treatment respectively. Figure 2.4 shows the effects of high fire severity: mid to late seral closed canopy forest conditions are reduced as a result of the fire resulting in vegetation type changes.

Figure 2.4 High fire severity near Moonlight Creek (Courtesy of C. Shannon 2007).

2.3 Air Quality Current Conditions

The Moonlight and Wheeler Project area is located in Plumas County, California. Nearby towns, communities, and highways are shown in table 2.5. The entire project area is contained in the Northern Sierra Air Quality Management District (NSAQMD) within the Mountain Counties Air Basin. The air quality attainment status for ozone, carbon monoxide, sulfur dioxide, and other compounds is listed in table 2.6 below. The attainment status was derived directly from the NSAQMD "Annual Air Monitoring Report" (2005).

Table 2.5. Towns, communities, National Parks, and highways in the vicinity of the Moonlight and Wheeler Fires Recovery and Restoration Project

Town or Feature	Distance and Direction from Wheeler Project Boundary
Susanville & Janesville	7 miles north
Greenville	7 miles west
Taylorsville	9 miles southwest

Genesee Valley	2 miles south
Chester	10 miles northwest
Quincy	18 miles southwest
Portola	20 miles southeast
Highway 89	7 miles west
Highway 395	2 miles east
Highway 36	5 miles northwest
Mt. Lassen National Park	>20 miles northwest

Table 2.6. Attainment designations for Plumas County.

Compound	National Attainment Status	State Attainment Status
Ozone (1 hour)	Attainment	Unclassified
Ozone (8 hour)	Attainment	Not applicable
Carbon monoxide	Attainment	Attainment
Nitrogen dioxide	Attainment	Attainment
Sulfur dioxide	Attainment	Attainment
PM_{10}	Unclassified	Nonattainment
$PM_{2.5}$	Unclassified	Nonattainment – only the Portola Valley is in nonattainment for the state $PM_{2.5}$ annual standard

Source: NSAQMD (2004)

Currently, Plumas County is in nonattainment status for particulate matter $(PM)_{10}$ (county wide) and $PM_{2.5}$ (Portola Valley only). The Project Area is 20 miles northwest of Portola Valley at its closest point. According to the NSAQMD 2005 report, the major contributors to both PM_{10} and $PM_{2.5}$ levels include forestry management burns, woodstoves, residential open burning, vehicle traffic, and windblown dust. These problems can be relieved or made worse by local meteorology, winds, and temperature inversions. In addition, large areas in and adjacent to local communities can be heavily impacted by smoke for extensive summer periods (several weeks) due to wildfire such as in the 3,500-acre Stream fire, 3,000 acre Boulder fire, and the Antelope Complex and Moonlight fires (USDA 2003). The community of Quincy is subject to strong inversions and stagnant conditions in the wintertime. Those conditions, coupled with intensive residential wood burning, can result in very high episodic $PM_{2.5}$ levels (NSAQMD 2005). Levels of PM_{10} have been greatly decreased due to a reduction of non-EPA (Environmental Protection Agency) approved woodstoves in existing residences. The NSAQMD (2005) report noted four key points relating to current air quality within the NSAQMD:

1. The NSAQMD's state and federal nonattainment status for ozone is due to overwhelming air pollution transport from upwind urban areas, such as the Sacramento and Bay areas.

2. Improvements in air quality, with respect to ozone, will depend largely on the success of air quality programs in upwind areas.

3. Anticipated growth in local population will add to locally generated pollution levels. Therefore, local mitigations are needed to prevent further long-term air quality degradations. Otherwise, the local contribution may increase to the point where the transport excuse will become less viable, and more emphasis will then be placed on mandated local controls.

4. State and federal land managers anticipate a marked increase in prescribed burning within the next 5 years. This may have a tremendous impact on local PM_{10} and $PM_{2.5}$ levels, unless appropriate mitigations are employed.

Current sources of particulate matter from the burned area include smoke from large wildfires, smoke from underburning and pile burning, emissions and dust from standard and off-highway vehicles, dust and emissions from harvest activities occurring on private lands, smoke from campfires, emissions from boats at Antelope Lake, and wind-generated dust from exposed soil surfaces. The amount and duration of these emissions vary by season, with most emissions from wildfires, timber harvest, and recreational activities occurring between May and late August, and emissions from prescribed burning occurring from late September through mid-November.

3. Analysis Framework

3.1 Guiding Regulations

The Moonlight and Wheeler Fires Recovery and Restoration Project is designed to fulfill the management direction specified in the Plumas National Forest Land and Resource Management Plan (PNF LRMP) (1988), as amended by the Herger-Feinstein Quincy Library Group (HFQLG) final supplemental environmental impact statement (FSEIS) and Record of Decision (ROD) (1999, 2003), and the Sierra Nevada Forest Plan Amendment (SNFPA) FSEIS and ROD (2004). Fuel and vegetation management activities are designed to comply with the standards and guidelines as described in the SNFPA FSEIS and ROD (2004).

National Forest Management Act

The National Forest Management Act (NFMA) of 1976, including its amendments to the Forest and Rangeland Renewable Resources Planning Act of 1974 state that it is the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans. Both acts also state "insure that timber will be harvested from national Forest System land only where – (ii) there is assurance that such lands can be adequately restocked within five years of harvest."

NFMA sets policy to maintain appropriate forest cover in accordance with forest plans (16 U.S.C. 1601 (d)) and requires best effort to reforest within 5 years after harvest (16 U.S.C. 1605 (g) (3) (e)). As it relates to wildfires (or any other natural disturbance) that create openings in the forest that need reforestation, it is agency policy to consider salvage harvest the functional equivalent of a regeneration harvest and to make a best effort to recover forested conditions within 5 years after harvest (Forest Service Manual 2470).

Relevant excerpts from NFMA state:

"Reforestation
Sec. 4. Section 3 of the Forest and Rangeland Renewable Resources Planning Act of 1974, as redesignated by section 2 of this Act, is amended by adding at the end thereof of new subsections (d) and (e) as follows:
"(d)(1) It is the policy of the Congress that all forested lands in the National Forest System shall be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans. Accordingly, the Secretary is directed to identify and report to the Congress annually at the time of submission of the President's budget together with the annual report provided for under section 8 (c) of this Act, beginning with submission of the President's budget for fiscal year 1978, the amount and location by forests and States and by productivity class, where practicable, of all lands in the National Forest System where objectives of land management plans indicate the need to reforest areas that have been cut-over or otherwise denuded or deforested, and best potential rate of growth. All national forest lands treated from year to year shall be examined after the first and third growing seasons and certified by the Secretary in the report provided for under this subsection as to stocking rate, growth rate in relation to potential and other pertinent measures. Any lands not certified as satisfactory shall be returned to the backlog and scheduled for prompt treatment. The level and types of treatment shall be those which secure the most effective mix of multiple use benefits."

"National Forest System Resource Planning
… (g) As soon as practicable, but not later than two years after enactment of this subsection, the Secretary shall in accordance with the procedures set forth in section 553 of title 5, United States Code, promulgate regulations, under the principles of the Multiple-Use, Sustained-Yield Act of 1960, that set out the process for the development and revision of the land management plans, and the guidelines and standards prescribed by this subsection. The regulations shall include, but not be limited to-
(3) specifying guidelines for land management plans developed to achieve the goals of the Program which-
(E) insure that timber will be harvested from National Forest System lands only where-
(ii) there is assurance that such lands can be adequately restocked within five years after harvest;".

Plumas National Forest Land Management Plan as amended by the Herger-Feinsten Quincy Library Group FSEIS and ROD (1999, 2003) and the Sierra Nevada Forest Plan Amendment FSEIS and ROD (2004)

The desired condition as described in alternative 2 of the HFQLG Final Environmental Impact Statement (USDA 1999) is an "all-aged, multistory, fire-resistant forest," but is silent in regards to fire salvage and reforestation. However, the majority of the project area meets the definition of "Capable, Available, and Suitable" lands for forest management under the HFQLG Pilot Project and reforestation activities would be congruent with keeping forestland forested.

The 2004 SNFPA provides management standards and guidelines for salvage in appendix D of the Record of Decision (USDA 2004). Appendix D directs the forests to "determine the need for ecosystem restoration projects following large, catastrophic disturbance events" (including wildfire) and that "salvage harvest of dead and dying trees may be conducted to recover the economic value of this material and to support objectives for reducing hazardous fuels, improving forest health, re-intoducing fire, and/or re-establishing forested conditions." Reforestation guidelines for Region 5 are addressed in the Reforestation Handbook (FSH 2409.26b, 4.11a).

Roadside Safety and Hazard Tree Guidelines

Forest Service Handbook (FSH) 7709.59 Chapter 40, Section 41.7 Hazard Identification and Correction, FSH 6709.11, 27.62d, and the Plumas National Forest Roadside/Facility Hazard Tree Guidelines specify the need to remove hazardous trees with structural defects likely to cause failure in all or part of the tree, which may fall and hit the road prism, in a timely, efficient, and cost-effective manner. The Forest Service routinely removes hazard trees to maintain roads for access and safety. The Plumas National Forest Roadside / Facility Hazard Tree Abatement Action Plan (2008) and corresponding removal guidelines provides direction on hazard tree identification and abatement, however, do not include identification criteria for recently affected fire-injured trees. It is reasonably anticipated that tree mortality associated with fire-injury may occur for years subsequent to the Moonlight Fire. Consequently, marking guidelines based upon tree mortality models from the latest scientific research by Fire Science Laboratory at the Rocky Mountain Research Station (Hood et al. 2007) were developed for this project in conjunction with Pacific Southwest Region Forest Health Protection Staff and would also be used to identify dying trees because these guidelines are specifically designed for fire-injured trees.

3.2 Methodology

3.2.1 Geographic Area Evaluated for Impacts

The Moonlight and Wheeler Fires Recovery and Restoration Project treatment units are defined as the units where timber salvage harvest and reforestation treatments would occur as described by alternative under chapter 2 of the draft EIS. The analysis area is defined as the 87,647 acre area where the Moonlight and Antelope Complex fires burned with the exception of the 82 acres of spot fires which occurred outside of the main fire perimeters. The analysis area is located in predominately Sierra mixed conifer forest ranging in elevation from approximately 3,800 feet in the North Arm of Indian Valley to 7,500 feet at the top of Eisenheimer Peak, largely along the cusp of the Transition and Eastside ecological zones (USDA 1999).

The analysis area used to analyze the direct, indirect, and cumulative effects on forest vegetation, fuels, and fire is the 87,647 acre fire perimeter where the Moonlight and Antelope Complex fires burned. The analysis area is based on 1) acres burned in a distinct geographic area and administrative setting, 2) impacts to forest vegetation from the wildfire and subsequent effects of timber salvage harvest and reforestation, including cumulative effects, are limited to the burned area, and 3) the area includes forest vegetation occurring within the treatment areas as well as the vegetation outside the treatment areas, but within the fire perimeter and represents the furthest measurable extent that effects on forest vegetation and fuels would occur as a result of implementing any of the proposed alternatives. Areas beyond the fire perimeter were not considered within the analysis area because including extensive areas of unburned forest would dilute the extent of impacts of the fire and post-fire activities.

Ecologically, the dynamics between vegetation and fire and fuels are inherently linked; fire has a profound effect on vegetation establishment and development and conversely, vegetation treatments (and the absence thereof) have a profound effect on fuels accumulations and fire behavior. The analysis area considers this relationship on the landscape level by including the entire fire perimeter of both fires, and allows for a congruent analysis of forest vegetation, fuels, and fire at the stand and landscape levels.

The direct, indirect, and cumulative effects analyses are based on a temporal scale. Documented past projects, including timber harvesting, wildfires, watershed improvements, and other activities described in Appendix B: Past, Present, and Reasonably Foreseeable Future Actions of the draft EIS ranging as far back as 1974 were considered past actions within the analysis area. In a broader sense, current vegetation structure and composition reflects the historical management regimes prior to 1974. This vegetation structure and composition includes attributes of the current landscape including existing vegetation types, fuel treatments, burned areas, past sanitation harvest, and plantations.

For the purpose of the vegetation, fire, and fuels analysis, the temporal bounds include a 30-year horizon for future effects because modeling indicates that, within 30 years, the treated stands would approach stocking levels corresponding with forest development. In addition, past stand replacing fires within the project vicinity such as the Elephant fire (1981) that were treated with similar management actions (salvage fire-killed timber and reforestation) developed into young forested stands within 30 years. This stand development is commensurate with the modeling performed in this analysis. Stand development modeling was extended beyond this to examine general trends and trajectories of stand development under no further management beyond those documented in Appendix B: Past, Present, and Reasonably Foreseeable Future Actions of the draft EIS.

The air quality analysis considers potential impacts to communities within 20 miles of the project area as these are the communities that would be most impacted by any activities within the alternatives. The temporal bounds are limited to the implementation phase of the project as direct, indirect, and cumulative effects would be limited to the timeframe in which proposed activities would occur.

3.2.2 Measurement Indicators

The effects of treatment on forest vegetation, fuels, potential fire behavior, and air quality are evaluated for each alternative.

The effects of treatment on forest stand structure, regeneration, forest products, and landscape structure are evaluated using the following measurement indicators for each alternative.

Trees per acre and their distribution by diameter class: The number and distribution of live and dead trees per acre by diameter class (table 3.1) is an important unit of measure because it shows the effect of treatments on different size trees and resulting stand structure. The four diameter classes are based on:

1. Significance of surviving and planted live trees to residual forest structure
2. Snag retention guidelines
3. Diameter classes for forest products (biomass and sawlog products)

Table 3.1. Diameter classes used for analysis

Live Trees	Regeneration	Surviving mid-story	Surviving Overstory	
Dead Trees	Dead trees <15 inches dbh		Medium snags	Large snags
Products	Biomass	Biomass (primarily)	Sawlogs	
Diameter Class	0-10 inches dbh	10-16 inches dbh	16-30 inches dbh	>30 inches dbh

Regeneration Attributes: Over the project area, percent of area expected to meet desired stocking levels and NFMA requirements is used as metric to determine how well each alternative meets the purpose and need for reforestation. The number of surviving planted trees per acre (live trees 0-10 inches in diameter in table 3.1) and the corresponding height and diameter growth of planted trees is an important measure because it displays the capacity of the actions to meet NFMA requirements and desired stocking standards as defined by the Reforestation Handbook (FSH 2409.26b, 4.11a). In addition, the height and diameter over time provide a metric of forest development which display development of forest habitat, and can easily be contrasted to forest succession and development with comparable past fires.

Miles of Road to Remove Roadside Hazard Trees: The estimated miles of road treated to remove hazard trees that have the potential to fall and cause damage to resources or people is used to assess the safety of using Forest Service roads in the forest environment. FSH 7709.58 and 6709.11, 27.62d sets standards and guides for the need for the removal of hazard trees along forest roads. This is an appropriate metric to measure safety and where treatments meet standards.

Estimated volume of forest products: The estimated volume of sawtimber and biomass material produced by each alternative contributes to the local community economy through offerings of timber sale and service contracts involving the removal of forest products from public lands. Consequently, this is an appropriate metric to measure how well each alternative meets the purpose and need of economic recovery.

Landscape Structure and Diversity: California Wildlife Habitat Relationships (CWHR) vegetation typing (Mayer and Laudenslayer 1988) and fire severity (Miller 2007; Miller and Thode 1997) are used to measure cumulative effects of alternatives on landscape structure and diversity. CWHR vegetation type, size class, and density is an effective proxy for seral stages and may be used to display the relative distribution of seral stages because it describes vegetation type, average tree size, and canopy cover. In addition, this allows for a congruent analysis of effects on forest vegetation and wildlife habitat. Fire severity may also be used as it describes the effects of the wildfire on forest vegetation, which in turn affects vegetation type, size class, and density. Effects of past, present, and future projects that focus on post-fire treatment (such as roadside hazard tree removal projects and fire-salvage projects) correspond to fire severity and therefore, relative percentages of fire severity affected by treatments is a relevant indicator to measure landscape diversity.

The effects of treatment on fuels, potential fire behavior, and air quality are evaluated using the following measurement indicators for each alternative.

Surface fuel load (tons per acre): The predicted surface fuel loads, as computed by the Forest Vegetation Simulator (FVS) and Fire and Fuels Extension (FFE) are reported under the direct and indirect effects for each alternative. The fuel loads are reported in tons per acre for the following fuel diameter classes: 1-3 inches, 3-6 inches, 6-12 inches, greater than 12 inches, and all fuels greater than 1 inch combined.

Predicted flame length (feet): The predicted (FVS-FFE) length of flame measured in feet. Increased flame lengths can increase fire intensity and the likelihood of torching events and crown fires. Flame length is influenced in part by fuel type, fuel arrangement, fuel moisture, and weather conditions. Fuel type and fire intensity, in turn, influence production rates, or how fast firelines can be constructed by different suppression resources, including hand crews and mechanical equipment. Flame lengths over 4 feet may present serious control problems—they are too dangerous to be directly contained by hand crews (Schlobohm and Brain 2002; Andrews and Rothermel 1982). Flame lengths over 8 feet are generally not controllable by ground-based equipment or aerial retardant and present serious control problems including torching, crowning, and spotting.

Predicted Percent basal Mortality: The predicted (FVS-FFE) percent probability of mortality for trees that may be killed by direct scorching of needles or cambial damage from a wildfire (Reinhardt et al. 1997) occurring under 90th percentile weather conditions.

Predicted Particulate Matter (PM)$_{10}$ (tons) and PM$_{2.5}$: Predicted amounts of particulate matter emitted from project is measured by PM$_{10}$ (county wide) and PM$_{2.5}$ (Portola Valley only) as forest management activities such as pile burning and underburning contribute to these levels.

3.2.3 Analysis Methods

Field inventories were conducted to measure attributes of existing vegetation in the project area. Treatments units within the project area were inventoried using the Common Stand Exam protocols for the Pacific Southwest Region (U.S. Department of Agriculture [USDA] Forest Service Region 5). These treatment units are representative of the project area and the areas to be treated in all action alternatives. Data was collected on live and dead trees. These data were used in the following analysis, data tables, graphs, and charts and are incorporated by reference.

Field inventory data from the treatment units was stratified by site class to best represent the range in average conditions between higher and lower sites and were used as input to the Forest Vegetation Simulator (FVS) and the Fire and Fuels Extension (FFE), a forest growth model that predicts forest stand development (FVS 1997; Dixon 1994). FVS-FFE is a well established tree and stand growth model that is supported and maintained by the Forest Service. A specifically calibrated variant of FVS is available for the Sierra Nevada. Stand development over time is modeled using existing stand conditions, as provided by post-fire field inventories. Salvage harvest and reforestation actions are modeled in order to provide estimates of future fuels, snags, and stand development based on realistic and predictable inputs. The model was used to quantify existing conditions and to predict the effect of alternative treatments on forest development. Model results are used to highlight relative differences, not absolute conditions. No future activities, fires, or natural regeneration events are included in growth simulations due to the variable and unpredictable nature of such events.

Geographic Information System (GIS) was used to analyze effects on forest vegetation on the landscape scale by using fire severity data, pre-fire CWHR data compiled by the VESTRA (2000) vegetation coverage, and the post-fire vegetation typing completed by Vegetation Management Solutions USFS Enterprise Team (2008) for the project area.

Natural Regeneration Discussion and Assumptions

Desired stocking levels

For the purpose of this project, the minimum desired stocking levels is between 75 and 150 established trees per acre. This range was derived using the minimum stocking levels as prescribed in the Reforestation Handbook (FSH 2409.26b, 4.11a) for Ponderosa/Jeffrey pine and mixed conifer types. These types were used to formulate an acceptable site specific range for the project area. The desired forest vegetation type is a pine dominated Sierra mixed conifer forest characteristic of native fire regimes within the east portion of the transition ecological zone. Minimum desired stocking levels should be met within five years after harvest as specified under the NFMA.

Factors affecting natural regeneration

Accurate predictions of natural regeneration are difficult to make and must be based on a number of assumptions. Factors that effect natural regeneration include:

1. The availability, location, and distance of surviving seed producing trees.
2. The periodicity of successful cone crops and abundance of seed produced, and the timing with which these factors coincide with seedbed receptiveness.
3. Seedbed conditions such as receptiveness and micro site availability effect the over wintering and germination of seeds, as well as seedling establishment, growth, and survival.
4. Animal and insect populations' affect numbers of seed and seed predation as well as fungi can affect seedling germination and survival.
5. Early growth and survival of seedlings may be affected by micro-site (frost & heat), precipitation, climate (drought), shading, and competing vegetation (primarily grasses and shrubs).

These factors that effect natural regeneration are both variable and difficult to predict. For example, the availability and abundance of seed in the canopy of fire killed or injured trees are variable as is the distance of surviving, seed-producing trees to unstocked areas. Cone and seed crops and the timing and abundance of seed from future cone crops are all variable and affect establishment of natural regeneration (Smith et al. 1997). Variation in seedbed receptiveness, micro-site availability, and moisture conditions in the seedbed affect seed germination, seedling establishment, and growth (Fowells and Stark 1965; Kemball et al. 2006).

However, reasonable qualitative assumptions based on scientific literature, field observations, and forest development after past fires can be made, and are necessary, in order to describe and compare stand development over time for each alternative.

Seed dispersal and seedling establishment

The historical rule of thumb is that most conifers can effectively disperse viable seeds and naturally regenerate areas within one and a half to two tree heights from the seed source (McDonald 1983; Smith et al. 1997). This conventional wisdom largely holds true particularly for species with larger, heavier seeds such as pine species (ponderosa, Jeffrey, and sugar pine) where the majority of seed falls within a hundred feet or so from the parent seed tree (USDA 1990 Agric. Handbook 654, Fire Effects Information System). Capacity to disperse seeds and naturally regenerate areas typically decreases exponentially at further distances (Greene and Johnson 2000; Nathan and Muller-Landau 2000; Smith et al. 1997); however secondary dispersal mechanisms such as dispersal by animals may increase dispersal distances (USDA 1990; Nathan and Muller-Landau 2000). The rule of thumb has also been applied to species such as Douglas-fir and white fir (Gordon 1979; McDonald 1983; USDA 1990). More recent peer-reviewed literature (Shatford et al. 2007), and observational studies (Nawa 2006) suggests that natural regeneration, particularly in species with lighter seeds such as Douglas-fir, white fir, and incense cedar, may occur much farther with greater quantities than once thought. However, Shatford et al. (2007) also recognized that "the establishment of conifers after wildfire was highly variable from year to year, and place to place, resulting in high variation in tree density and size."

Field experience and observations from many local silviculturists and culturists confirm that sites closest to the surviving seed source have the greatest capacity for natural regeneration, particularly the preferred species such as pine, and this capacity diminishes the farther the distance from the “edge” or seed source increases. Capacity for long distance seed dispersal resulting in natural regeneration relies more heavily on the coincidental occurrence of several of the aforementioned factors being favorable. While natural regeneration closest to the edge is more reliable, depending on the coinciding alignment of favorable seed development, dispersal mechanisms, seed bed receptiveness, and microsite conditions (such as aspect, soil moisture, light levels, and presence/absence of competing vegetation) for successful establishment and growth adds uncertainty and a large degree of variability to the capacity for longer distance regeneration.

Natural regeneration establishment in past local fires

For example, surveys of natural regeneration more than five years after the Bucks fire and Devil’s Gap fire on the Plumas National Forest indicate that most of the natural regeneration that met desired levels occurred within approximately 200 to 300 feet of the edge, depending on the height of the nearest surviving stand. In addition, larger areas that burned in the Devil’s Gap fire did not have enough natural regeneration to meet desired national stocking levels. For every 300 acres surveyed, only approximately 100 acres could be certified to meet national and regional tree stocking requirements (Gott, J., personal communication 2008).

The Cottonwood fire burned more than 46,000 acres of the Tahoe and Humboldt-Toiyabe National Forests. This fire occurred approximately 50 miles south of the Wheeler Fire on the east side of the Sierra Nevada Range. Timing of this large fire coincided with one of the most favorable pine cone crops noted in the recent past. Natural regeneration around the edges of the fire numbered in the thousands of seedlings per acre; however, areas in the middle of large high severity areas did not have natural regeneration deemed sufficient to meet desired stocking levels. District reforestation personnel from the Sierraville Ranger District (Tahoe National Forest) estimate that despite the bumper cone crop, only approximately one-third of the area successfully regenerated naturally meeting desired tree stocking levels (Weaver, S., personal communication 2008).

In 2000, the Storrie fire burned over 55,000 acres. Received comments (Hanson project comment letter 2007) suggest that areas are successfully naturally regenerating; While this has also been recognized by Forest Service professionals, the commenter’s interpretations of patterns of natural regeneration across the reforestation area are not necessarily valid as sampling was limited due to small sample size (less than 1/22,000th of the area was sampled) and plots locations were limited due to “accessibility”. Field observations from post-fire stand exams performed by USFS reforestation personnel indicate areas of successful natural regeneration occur near the edge with longer distance dispersal by white fir and incense cedar. However, notable areas in high severity burn patches did not have sufficient natural regeneration (O’Hanlon, R., personal communication 2008 & Smith, B., personal communication 2008). It should also be noted that in the summer of 2008, a number of lightning fires “re-burned” within the footprint of the 2000 Storrie Fire resulting in mortality of established natural regeneration and existing live trees which could have provided a seed source. These “reburn” fires could have additional negative effects by creating a landscape devoid of natural regeneration or trees capable of naturally regenerating the site.

Natural regeneration establishment in Moonlight and Antelope Complex Fires

During the summer of 2008 and the spring of 2009, numerous Forest Service professionals, including foresters, culturists (reforestation specialists), botanists, and site visits with regional silviculture staff have covered thousands of acres of the Moonlight and Antelope Complex fires through the course of project assessments, unit preparation, reforestation activities, and surveys. All of these professionals have noted the lack of natural regeneration of conifers, particularly within the large areas that burned with high fire severity where few surviving trees exist (personal communications B. Smith 2008, L. Smith 2008, Belsher-Howe 2008, Coppoletta 2008, Landram 2008) Within the Moonlight and Antelope Complex fires, natural regeneration does exist; however, this natural regeneration is limited in large areas of high fire severity, and is highly variable dependent on the degree and size of fire severity and number and proximity of surviving trees capable of producing viable seed. This is consistent with observations from past fires as noted above.

Cone collection efforts indicate that the 2008 cone crop is generally a light to moderate year and overall is less than what would be considered a “banner” year. The ponderosa pine and Jeffrey pine cone crop was poor due to poor seed set and insect occurrence (seed midge). The Douglas-fir cone crop was generally poor due to a frost event in the spring and the incense cedar cone crop was light to poor. The sugar pine cone crop was light to moderate this year; however the abundance of conelets suggest that next year could be a good year dependent on weather patterns and cone-insect populations. The white fir and red fir cone crops were scattered. (personal communication P. Stover 2008). This suggests that capacity for natural regeneration may less than optimal.

Natural Regeneration Assumptions

For the purposes of this analysis, effective seed dispersal distances for pine species are assumed to be within one and a half to two tree heights (for a 125 ft site tree: 188 to 250 feet) from the edges of surviving stands. This would be slightly less than distances observed on the Devil’s Gap and Bucks Fire since average stand heights are smaller within the Moonlight Antelope area due to generally lower site quality. While effective seed dispersal distances for Douglas-fir, white fir, and incense cedar are assumed to be slightly farther, approximately 600 feet from the edges of unburned stands and stands that burned with low to moderate severity, such naturally regenerated stands would not likely contain a proportion of pine species that would meet desired conditions. The areas farther from seed sources, especially those large areas that burned at high severity may regenerate, but would take a longer period (potentially decades) and have more variable success in meeting desired stocking standards.

In addition, a strategy reliant solely on natural regeneration would likely not establish desired levels of stocking or desired species within acceptable temporal bounds considering the interaction of the aforementioned variables that affect natural regeneration. Considering this, and the fact that any naturally occurring regeneration may also be damaged by salvage harvest operations proposed in the action alternatives

(Donato et al. 2006), all action alternatives include reforestation utilizing a wide spaced low density cluster planting. The cluster planting is designed to establish minimum stocking levels of desired species appropriate for the native ecological forest type at a density high enough to meet desired stocking levels, but low enough to compliment any natural regeneration that may occur. The cluster arrangement is also designed to be congruent with variable seedling survival to produce a planting that mimics the heterogeneity and pattern of a naturally occurring forest.

Fire Weather Discussion and Assumptions

The modeling of potential fire behavior was done under 90th percentile weather conditions (table 3.2) that were calculated using Fire Family Plus (Main et al. 1990). The 90th percentile weather is defined as the severest 10 percent of the historical fire weather conditions occurring during the fire season. The Pierce weather station was used to compute 90th percentile fire weather conditions. This weather station is located 6 miles northwest from the project area and best predicts local historical and current weather patterns in the analysis area.

Table 3.2. Parameters used for stand-level modeling under 90th percentile weather conditions.

Weather Variable	Value	Weather Variable	Value
Weather Station Name and ID Number	Pierce (# 040915)	Temperature (Fahrenheit)	91°
Time of Year	June 30 to September 15	Herbaceous fuel moisture	30%
1-hour fuel moisture	1.9%	Woody fuel moisture	70%
10-hour fuel moisture	2.5%	Probable maximum 1 minute 20-foot wind speed[a]	10 mph
100-hour fuel moisture	4.6%	Foliar (leaf) moisture content[b]	90%
1,000-hour fuel moisture	6.1%	Wind reduction factor[b]	0.4
Relative Humidity	10%		

Sources:

a. Crosby and Chandler 1966

b. Stephens and Moghaddas 2005a, b; Agee et al. 2002

c. Rothermel 1983

3.2.4 Design Criteria

Chapters 1 and 2 of the draft EIS provide detailed information about the design criteria used for each alternative.

The harvest systems were determined by evaluating topography, slope, and access for each unit. Ground based mechanical, skyline, and helicopter harvest systems are proposed under the two action alternatives (chapter 2 of the draft EIS). All harvest operations would adhere to the standards and guidelines set forth in the timber sale administration handbook (FSH 2409.15 including Region 5 supplements) and the Best

Management Practices as delineated in the Water Quality Management for Forest System Lands in California: Best Management Practices (USDA 2000).

For both action alternatives, marking guidelines would focus on the removal of fire-killed (dead) trees and the retention of live trees. No fire-injuredd and/or dying live trees would be designated for removal under the silvicultural prescription; however, incidental removal of live trees may be necessary in order to facilitate the operability of harvest operations such as the construction of skid trails, landings, and temporary roads. In addition, snags (fire-killed/dead trees) would be retained in designated snag retention areas within the treatment areas. The treatment units are designed to encompass large areas of high severity where the vast majority, if not all, trees within the stands are dead and economic recovery treatments are appropriate. These units include small inclusions of areas that burned with moderate fire severity (50 to 75 basal area mortality) which occur around the edges ("the rind") or as islands around/within larger areas that burned with high fire severity. However, the emphasis of the salvage and reforestation treatments are focused on the larger areas that burned with high severity.

3.2.5 Type and Duration of Effects

Direct Effects. These are effects on forest vegetation that are directly caused by treatment implementation or, as with alternative B (no action), a lack of treatment.

Indirect Effects. These are effects on forest vegetation that are in response to the direct effects of treatment implementation or, as with alternative B (no action), a lack of treatment.

Duration of Effects. Direct effects would likely be limited to the project implementation phase. Indirect effects would last beyond the implementation period and occur within the temporal bound of the cumulative effect analysis described above in section 3.2.1 (Geographic Area Evaluated for Impacts).

4. Environmental Consequences

4.1 No Action Alternative: Alternative B

4.1.1 Direct and Indirect Effects – Alternative B

Existing stand conditions would persist and develop unaltered by active management. Standing snags would persist and the site would be rapidly colonized by grasses, forbs, and shrubs within three to five years. It is a reasonable expectation that the site would develop comparable to that of similar local fires that burned in the recent past where salvage did not occur including the Mt. Hough Complex (1999), the Storrie fire (2000) and the Stream fire (2001). On these sites, grasses such as cheat grass and shrubs such as Ceanothus (*C. cordulatus, C. velutinus*) and Manzanita (*Arctostaphylos patula*) species have occupied the site while standing snags dominate the overstory of the high severity burn areas. Shrub fuels would be established within 10 years.

Table 4.1 displays the existing and projected stand structure within proposed treatment units under the no action alternative. Hundreds of dead trees and very few live trees per acre characterize the forest structure. Snag fall rates are highest the first ten years within the smaller diameter classes, while larger snags persist for relatively longer time periods which is generally documented in existing scientific literature (Cluck and Smith 2007). Nearly all snags would be expected to fall by approximately 20 years post-fire contributing to greater fuel loads. The limbs and boles from these fallen trees would accumulate as surface fuels (table 4.2). Over time, this fuel is expected to increase each decade as trees fall over. Within 10 years, surface fuels up to 12 inches in diameter are projected to be 14 tons per acre. Within 30 years, surface fuels up to 12 inches in diameter are projected to average 17 tons per acre due to dead trees falling over.

Additional snag recruitment would be expected through delayed mortality in the few live trees per acre. Those live trees injured during the fire may be more susceptible to biotic and abiotic agents that hasten delayed conifer mortality due to reduced tree vigor. This phenomenon has occurred on past local fires (Storrie 2000, Stream 2001), and is well documented in the scientific literature (Ryan and Reinhardt 1988, Hood et al. 2007, Filip et al. 2007).

Table 4.1 Existing and projected stand structure for alternative B, the no action alternative.

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Basal Area
	Total	0-10"	10-16"	16-30"	>30"	Total	0-10"	10-16"	16-30"	>30"	
Alternative B: No Action (Site V) -- No Salvage Harvest, No Reforestation											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Harvest	--	--	--	--	--	--	--	--	--	--	--
Post	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
10 years	9.4	0.0	5.8	3.4	0.2	139.3	98.6	29.1	9.9	1.8	16
20 years	9.2	0.0	2.4	6.2	0.4	22.2	4.3	10.2	6.1	1.5	20
30 years	9.0	0.0	0.1	8.2	0.4	4.5	0.0	0.4	2.9	1.3	24
Alternative B: No Action (Site III & IV) -- No Salvage Harvest, No Reforestation											
Existing	11.6	2.1	4.1	3.8	1.0	434.7	354.1	40.9	32.9	5.7	23
Harvest	--	--	--	--	--	--	--	--	--	--	
Post	11.6	2.1	4.1	3.8	1.0	434.7	354.1	40.9	32.9	5.7	23
10 years	10.4	1.5	3.8	3.7	1.3	200.4	148.4	23.5	22.7	5.0	24
20 years	10.0	1.0	3.6	3.9	1.4	40.1	13.2	8.0	14.2	4.4	26
30 years	9.6	0.8	2.2	4.9	1.5	10.8	0.1	0.6	6.2	3.8	28

Note: Stands combined for all harvest systems.

Table 4.2. Predicted surface fuel, flame length, and basal area mortality for the no action alternative.

		1 to 3 Inch Diameter Surface Fuels	3 to 6 Inch Diameter Surface Fuels	6 to 12 Inch Diameter Surface Fuels	Greater than 12 Inch Diameter Surface Fuels	All Surface Fuels	Predicted Flame length	Predicted Percentage of Basal Area mortality
Treatment Type	*Time frame*	*Tons per Acre*	*Tons per Acre*	*Tons per Acre*	*Tons per Acre*	*Tons per Acre*	*(Feet)*	*%*
No Action	Existing	2.6	2.8	3.2	0.5	9.1	4.0	58.3
No Action	10 years	2.8	4.3	7.0	4.9	19.0	7.7	93.2

No Action	20 years	2.6	4.9	10.4	10.0	27.9	10.7	95.3
No Action	30 years	2.4	4.3	10.3	12.4	29.5	10.9	94.3

The Stream fire serves as the best example of direct and indirect effects as it is immediately adjacent to the project area and burned in 2001. Approximately a third of the Stream fire was salvage harvested; however, the unsalvaged areas are characterized by standing snags and are dominated by ceanothus brush species. South and west aspects tend to have less shrub cover (estimated 30-50 percent) in an intermix mosaic with areas heavier to grass and forb cover, while north and east aspects are more heavily dominated by brush (estimated 50 percent cover with some sites up to 70 percent cover).

Both grass-forb cover and shrub cover presents formidable competition for water and light with naturally established and planted seedlings. This competing vegetation would likely result in decreased survival of tree seedlings and would definitely inhibit growth for years if not decades. Consequently, the site would likely be occupied by brush with an intermix of grass and forbs. Over time, ladder and crown fuels would develop where establishment of natural regeneration via seed from mature conifers that survived the fire.

Predicted flame lengths and percent of basal area killed are displayed in table 4.2. Under the no action alternative, flame lengths exceed 4 feet and are projected to exceed 10 feet within 30 years. These increased flame lengths are a direct result of fire burning in dead and down logs, branches, and shrubs. Fires burning in stands under 90th percentile weather conditions (table 3.2) in the no action alternative are expected to result in mortality exceeding 90 percent of live basal area. Under the no action alternative, this general trend in high flame lengths (>10 feet) and corresponding high tree mortalily (>90 percent) is expected to continue at least 20-30 years into the future.

Smoke from No Action

Under the no action alternative, there would be no pile burning and no underburning, therefore, there would be no smoke directly generated management activities. It is expected that there will continue to be lightning and human caused ignitions within the perimeter of the Moonlight and Antelope Complex fires- where these wildfires cannot be contained and they burn into heavy fuels, it is expected that heavy smoke from fire burning or smoldering in jack-strawed logs would result. This smoke would be blown to the northeast towards Susanville and Janesville by typically southwest winds during the day. At night, smoke from a fire in this area would move down the Indian Creek drainage and likely cause impacts to the community of Genesee Valley.

Roadside Hazard from No Action

Existing conditions along all traveled roadways within the Moonlight fire perimeter would persist and are predicted to alter roadways and create an unsafe environment for forest users, contractors, and Forest Service employees. In terms of forest vegetation and stand condition along the roadside corridor, the stands would persist as depicted in Table 4.1 and as described above. However, the fact that the trees along the roads within the Moonlight Fire pose a serious threat to all persons using the forest in any capacity make this an issue of safety.

Most snags are expected to fall within 25 years post-fire (BE/BA Moonlight RSHTR). Based on 30 years of local experience and observation from district staff of snagfall in the Will (1979) and Elephant (1982) fires, it is noted that fire-killed stands tended to have higher and faster rates of snagfall than the "natural background mortality" snagfall. These local observations are generally consistent with trends described in the Russell (2006) study showing that fire-killed snags have lower half lives and that snags fell much faster in areas that had been logged. Also, a Chambers and Mast study (2005) suggests differences in burned and unburned snag fall rates concluding that burned snags fell faster at a higher rate than unburned snags. Therefore, the assumption in the BE/BA is reasonable and reflective of local conditions. Furthermore, the Russell (2006) study showed that ponderosa pine and Douglas-fir, two of the most common occurring species killed in the Moonlight fire, have a half-life of 7 – 16 years depending on whether the area had been salvaged logged or not with ponderosa pine predicted to fall sooner than Douglas-fir.

Forest Health and Protection (FHP) monitoring of fire-injured trees has revealed the failure of 8-inch to 24-inch DBH red and white fir, with green crowns, in as little as three years with the rate of failure increasing dramatically after the fourth year post-fire, especially in conjunction with high winds or heavy snows (Cluck 2007).

Dahm (1949) studied the fall rate of ponderosa pine snags. When considering all trees within Dahm's study site, 78 percent of the trees had fallen 22 years post fire with an average of 3 trees per acre still standing. In the Moonlight fire roadside areas there are approximately 297 snags per acre in all size classes and 74 trees per acre in trees above 10-inches DBH. The 297 snags per acre were taken from stand exam and cruise data from the Moonlight RSHTR project and is an average over all severity classes. If in 22 years 78% of all snags had fallen in the roadside area, 231 trees per acre would have fallen with 58 trees per acre of those 231 being over 10-inches DBH. The roadside area makes up 4,389 acres of the entire Moonlight and Wheeler Fires Recovery and Restoration Project. Using the same parameters above, 1,013,859 trees would be on the ground in the roadside areas with 254,562 of those trees being over 10-inches DBH. Delayed conifer mortality would contribute to more snags with potential to fall within these areas. This underscores the long-term risk and potential for hazard trees to persist along these access routes, compromising safety for decades in the absence of treatment.

In another study by Passovoy and Fule (2007) 55 trees per acre remain standing 27 years post fire. However, the number of snags per acre is misleading due to the high number of Gamble oak snags, a hardwood species that does not occur in the project area, that remain standing at year 27. This overestimates the conifer snags that remain standing in the study area. Although California black oak is a species that exists in the Sierra Nevada, it is an infrequent and incidental species within the project area. Of the conifer species that are applicable to the project area, namely ponderosa pine and Douglas-fir, the snags that remain standing at year 27 are much more reduced from the 55 per acre in Passovoy and Fule. In their own abstract, the authors conclude that "Few fire created snags remained by the 27th year post fire."

Under Alternative B, trees remaining in the roadside corridor in the Moonlight fire are expected to fall within 25 years post fire. While this will provide more habitat for various wildlife species (Russell 2006), snags remaining within falling distance of the road will present a better likelihood of damage to roads and injury or fatality to anyone using these roads due to the higher concentration of people on roads verses in the general forest area.

4.1.2 Cumulative Effects Common to All Alternatives

In order to understand the contribution of past actions to the cumulative effects of the proposed action and alternatives, this analysis relies on current environmental conditions as a proxy for the impacts of past actions. This is because existing conditions reflect the aggregate impact of all prior human actions and natural events that have affected the environment and might contribute to cumulative effects.

This cumulative effects analysis does not attempt to quantify the effects of past human actions by adding up all prior actions on an action-by-action basis. Focusing on individual actions would be less accurate than looking at existing conditions because there is limited information on the environmental impacts of individual past actions, and it is not reasonably possible to identify each and every action over the last century that has contributed to current conditions. By looking at current conditions, the Forest Service is sure to capture all the residual effects of past human actions and natural events, regardless of which particular action or event contributed those effects. The Council on Environmental Quality issued an interpretive memorandum on June 24, 2005, regarding analysis of past actions, which states, “agencies can conduct an adequate cumulative effects analysis by focusing on the current aggregate effects of past actions without delving into the historical details of individual past actions.” For these reasons, the analysis of past actions in this section is based on current environmental conditions.

Past Projects. The cumulative effects of past management practices, fire exclusion, and high-mortality fires (appendix B) have largely shaped forest structure prior to the Moonlight and Antelope Complex fires. On public and private lands, past harvest activities focused on removal of dominant and codominant trees and retention of biomass and even-aged management. During the Moonlight and Antelope Complex fires, much of the area in this condition (high fuel loads, high stand density) burned with high severity (Fites et al. 2007). Post fire, these areas are now dominated by dead trees with little surface fuel other than litter, twigfall, and down burned logs and will likely become dominated by shrub species within the next decade. Overall, past harvesting which focused on removal of live dominant and codominant trees, retention of biomass, and no treatment of surface fuels combined with completely untreated reserve areas, contributed to high severity fire patches of fire in the analysis area.

Since 1996, commercial thinning from below, with and without prescribed fire, has been the principal silvicultural treatment implemented on public lands in the analysis area. This silvicultural treatment has been used to establish several fuel treatments within the analysis area (Hungry, Antelope Border, North Antelope, Pinebelt, Stony, and Dry Flat Projects). These areas were treated to meet desired conditions in terms of potential fire behavior and tree mortality. During the Moonlight and Antelope Complex fires, all of these treatments were impacted by the fire (Fites et al. 2007). A report completed after the fire concluded that 1) treated areas were utilized during suppression along several flanks of the fire for both direct attack with dozers and handcrews, as well as for indirect attack with burn operations, and 2) treated areas that burned during the first two days—when suppression resources were limited and fire behavior more uniformly intense—had reduced fire effects compared to untreated areas. In some areas, these treated sites had moderate to high severity effects (Fites et al. 2007). Today, these treated areas typically have many live trees, some newly created snags, and surface fuels composed primarily of litter fall from scorched trees. Overall, past fuel treatments resulted in patches of lower fire severity within the analysis area.

Wildfire Suppression and Fireline and Burned Area Emergency Rehabilitation (BAER) Efforts. Suppression tactics taken during the Moonlight and Antelope Complex fires affected forest vegetation and fuels. The tactics included air drops of water and retardant, back burning, construction of control lines by bulldozers and hand crews, live and dead tree falling, and construction of staging areas, safety zones, escape routes, and drop points. These suppression tactics altered forest vegetation largely through removal of vegetation and/or fuel accumulations or re-arrangement of fuels. Due to the linear, localized, and dispersed effects of these activities, there is a negligible effect on remaining forest vegetation and fuels.

In addition, fireline and BAER rehabilitation efforts were implemented to reduce negative effects of these activities within the fire areas. Fire suppression rehabilitation activities include rehabbing roads, helispots, safety zones, and water sources to pre-incident conditions; applying erosion control measures such as waterbar construction to dozer and handlines, pulling vegetative debris back onto control lines, and removing debris deposited in stream channels as a result of suppression efforts.

BAER treatments within the analysis area included improvement of drainage structures, including culverts, to accommodate increased flows and debris resulting from the Moonlight and Antelope Complex fires. These fireline and BAER rehabilitation treatments are also localized and dispersed across the landscape and have negligible to no measurable effects on forest vegetation, fuel loading, fire behavior, fire severity, or air quality.

Roadside Safety Projects. The roadside hazard trees are currently being removed within the Antelope Complex fire area under the Sage, Antelope, Last Chance, and Dry Flat Roadside Safety and Hazard Tree Removal Projects. The purpose of these projects is to provide for safe travel along roads within the fire areas. Under these projects, fire-killed and fire-injured trees expected to die within three years are removed resulting in a reduction of standing snags near the roadway. Since these projects are limited to 150 to 200 feet on either side of the road, these effects are localized and restricted to roadsides, approximately 11 percent of public lands within the analysis area. This calculation represents the maximum and furthest extent of measurable effects on forest vegetation that would occur as a result of implementing these projects. Since the removal of hazardous, fire-killed and fire-injured trees would only occur within striking distance of roads and facilities under these projects, the effects would be limited to these areas, and subsequently, dispersed across the 87,647 acre analysis area resulting in a minimal scale of effects. Due to the limited and dispersed nature of these effects, these activities would not substantially affect forest vegetation, fuel loading, fire behavior, or air quality on the stand or landscape level.

Post-fire salvage projects. The Camp 14 and North Moonlight projects are fire salvage projects proposed by the Beckwourth Ranger District, Plumas National Forest, and the Eagle Lake Ranger District, Lassen National Forest, respectively The Camp 14 project is completed while the North Moonlight project is currently under contract and ongoing. These fire salvage projects are limited to less than 250 acres in size, and occur in separate watersheds. Both of these projects include harvesting fire-injured trees in the interest of capturing the value of those trees which were substantially damaged by the fire and likely to die in the near future; however, since these projects also primarily target areas of high to moderate burn severity where greater than 50 percent of the basal area was killed, most trees harvested would be dead, fire-killed trees. The contributions of these two projects to cumulative effects include a localized reduction in snags, in snag recruitment from fire-injured trees, and in high burn severity forest structure. These two projects would affect 0.7 percent of public lands within the analysis area and represent the smallest contribution towards cumulative effects to forest vegetation, fuel loading, fire behavior, or air quality within the analysis area. Due to the size, scale, and, in the case of Camp 14, the dispersal of such activities, these localized effects would be minimal when considering the extent of the analysis area.

Reforestation projects. Reforestation of national forest lands where no salvage harvest is proposed began within the analysis area in spring 2008. A combination of low density wide spaced cluster planting in the Antelope Lake and Babcock Peak areas and low density square-spaced planting in the Camp 14 area occurred within areas of high fire severity accounting for a total of approximately 838 acres planted in 2008. During the summer of 2008, the Frazier Cabin Reforestation Project included 141 acres of mechanical site preparation which accounts for 0.16 percent of the analysis area and consequently results in a negligible contribution to cumulative effects. Approximately 10,500 acres of high severity, unsalvaged areas were planted in Spring 2009 across the Mt. Hough and Beckwourth Ranger District portions of the Moonlight and Antelope Complex fires utilizing a combination of low density planting arrangements. These additional acres of reforestation occurred in unsalvaged areas of the fire including old plantations and natural stands. Manual release treatments would occur within one to two years following planting. The net cumulative effect would be the enhanced establishment of conifer seedlings across the analysis area in order to re-establish forested conditions.

Post-fire Salvage and Reforestation on Private timberlands. Private lands account for over 19,000 acres or approximately 22 percent of the analysis area. Since fall 2007 through the present, fire salvage harvest has been occurring on these lands. Approximately 4,073 acres were planned for salvage harvest in 2007 and fire salvage timber harvest plans filed to date in 2009 account for an additional 7,381 acres approximately. Based on current activity, private fire salvage projects occur mostly on productive, well-stocked stands that burned with moderate to high burn severity resulting in a notable reduction in densities of fire-killed and fire-injured trees on private lands. It is reasonably assumed based on state forest practice regulations and private timber practices that these areas would be re-planted and managed for maximizing tree growth. Figure 4.1 displays representative fire-salvage and reforestation practices and effects common on private timberlands six years after the Storrie fire (2000) on the Plumas National Forest.

Figure 4.1 Boundary of National Forest and Private timberlands in the Storrie Fire. National Forest (on the left) was not treated. Private timberland (on the right) salvage harvested fire-killed and fire-injured trees and replanted. (Courtesy of R. O'Hanlon 2006).

Future HFQLG Projects. Future Herger-Feinstein Quincy Library Group projects that may occur within the analysis area include the Wildcat Project (2009) and the Keddie Project (2009). These projects would include Defensible Fuel Profile Zone fuel treatments, area thinning treatments, and group selection treatments which would involve timber harvesting and include silvicultural prescriptions which involve thinning from below to reduce hazardous accumulations of ladder and canopy fuels and promoting shade intolerant species. These projects would focus on harvesting green trees and would likely be modified to avoid areas affected by the fire; particularly areas that burned with moderate to high severity. Contribution to cumulative effects would include localized reduction of stand densities through timber harvest focusing on the removal of trees less than 30 inches diameter and the removal of snags. No treatment units from either the Wildcat or Keddie projects would overlap with treatment units in any action alternatives. Approximately 155 acres of these projects (75 acres from the Wildcat Project and 80 acres from the Keddie Project) may occur within the analysis area; this would account for 0.2 percent of the project area. Consequently, the contribution of these projects to cumulative effects would be negligible since 1) treatments would occur in low severity areas, 2) prescriptions would be focused on maintaining mature forest cover and reducing hazardous fuel conditions, 3) the units are geographically disparate, and dispersed from the action alternatives, and 4) the vast majority of the units occur outside of the analysis area and the perimeter of the fires.

Christmas Tree and Firewood cutting. Due to partial to complete scorch of most small trees (less than 10 inches in diameter) Christmas tree cutting would likely be limited within the analysis area; any negative effects from Christmas tree cutting would be highly dispersed and negligible. Firewood cutting will likely be limited as firewood cutters prefer not to cut trees that have blackened bark, and are only allowed to cut dead trees within 100 feet of the roads. In addition, the quality for firewood would deteritorate over time, making this area undesirable for firewood cutting. Overall, Christmas trees cutting and fuel wood cutting, would have a negligible effect on future stand and landscape-level forest vegetation, fuel loading, fire behavior, fire severity, or air quality due to the limited, highly localized, but largely dispersed nature of these activities. As a result cumulative effects would be negligible and immeasurable on a per acre basis.

Recreation. Under all alternatives, accessibility in the area to motorized traffic and recreation visitors would be maintained. Popular activities include camping, off-highway vehicle (OHV) based recreation, and hunting. OHV use can compact the soil and cause erosion which may negatively effect plant growth and establishment. OHV use can also damage and/or kill natural regeneration through crushing or compaction; however due to the dispersed nature of this type of recreation, the effects would be highly localized and have little to no measurable effect on forest vegetation across the analysis area. The primary effect of recreation activities, with respect to forest vegetation and fire, is the potential for ignition sources from campfires, vehicles, and other intentional or unintentional ignitions from forest users during summer months. It may be reasonably anticipated that recreational use within burned areas will decrease in the near future due to public safety and aesthetic issues in the burned area, resulting in fewer ignitions from human causes over the short term. As a result cumulative effects would be negligible and immeasurable on a per acre basis.

Livestock Grazing. Within the nine active grazing allotments in the fire perimeters there is expected to be minimal impacts to forest vegetation due to the following reasons: 1) cows did not graze burned areas in 2008, the season after the wildfires, therefore vegetation have had a full year of rest to resprout, 2) the increase in transitory (upland) range 2-5 years after the fires may take some grazing pressure off of the meadows and riparian areas with a flush of dryland grass/forbs that livestock may find palatable, and 3) long term recovery will be unimpeded through strict adherence to use standards which are: 20% willow use, 20% aspen use, 20% bank alteration, and 50% meadow use. Cows are removed from the pasture when any one of these triggers are reached. In addition, the Lower Lone Rock Creek watershed is scheduled to have a 1.5 mile temporary electric fence constructed in spring, 2009, before the cattle are turned out, which will prevent grazing in that reach of the watershed, further allowing forest vegetation, riparian vegetation and streambanks to recover.

Grazing in upland areas may be limited due to amounts of forage; however some damage and/or mortality may occur to natural regeneration and planted tree seedlings due to crushing or compaction from animals. Based on the existing stocking rates, the season of use, and the distribution of primary range across the project area, this is expected to be negligible due to scale and primary locality of the livestock.

4.1.3 Cumulative Effects – Alternative B

Under the no action alternative, the harvesting of fire-killed and fire-injured trees would be limited to the roadside hazard projects currently underway in the Antelope Complex fire area. The maximum extent of these activities would be limited to approximately 150 to 200 feet of either side of the roadways—roughly 5 percent of the public lands within the analysis area (table 4.3a). This would provide for safe travel along forest roads; however, due to the scale and scope of the project, large areas of untreated burned areas would exist. Brush species and standing snags would dominate these areas, and, over time, these snags would fall resulting in a brush field with high fuel loads arranged in a jackstraw pattern.

Under alternative B, approximately 5 percent of NFS lands would be subject to timber harvesting under other completed, current or proposed projects accounting for 5 percent of all NFS lands that burned with high severity (Table 4.3a). Timber harvesting to recover economic value of fire-killed trees would not occur on 95 percent of public lands in the analysis area and 95 percent or those NFS lands that burned with high severity. Areas proposed for treatment under alternatives A, C, D, or E would remain untreated and would assume a passive management strategy (no action). Although all alternatives leave large areas of these fires largely untreated under a passive management strategy; alternative B (the no-action alternative) proposes to leave the largest proportion of the landscape untreated.

Cumulatively, alternative B would affect 18 percent of all acreage within the analysis area through post-fire harvesting activities (table 4.4a). The majority of the acreage comes from private land harvest within the analysis area.

Under alternative B accessibility would limit future forest management activities (including cultural treatments to enhance survival and growth of natural regeneration) due to the high cost and safety concerns. Without cultural treatments, survival and growth of natural regeneration that does become established would likely be reduced due to competing vegetation. These sites would be dominated by brush very similar to those effects seen on public lands in the Storrie fire (2000) (figure 4.1) and observed in past fires (Bucks Summit 1926, Mt. Hough Complex fires 1999, Stream fire, 2001). This could effectively function as a vegetation type change from forest cover to brush cover for nearly a century based on observations from areas left to naturally regenerate in the Bucks Summit fire of 1926. Over eighty years later, these areas support natural establishment of white fir; however, the area is dominated by brush species and the tree cover is not sufficient to qualify as forest cover.

The no action alternative would not implement salvage harvesting and consequently would not provide for short-term local economic benefit by creating jobs from the sale of dead merchantable trees. Failure to salvage harvest dead trees within one to two years of the fire event results in rapidly diminished wood value (Lowell and Parry 2007), and this further reduces contributions to the local and regional area economy.

In addition, alternative B would not implement reforestation treatments such as planting and subsequent release treatments to improve survival and growth of established trees. The no-action alternative would solely rely on natural regeneration to re-establish forested conditions. Table 4.3b displays the percent of acres affected by the proposed and current post-fire reforestation treatments under alternative B. Under alternative B approximately 12 percent of public lands would be reforested under other current or proposed reforestation projects accounting for 18 percent of all public lands that burned with high severity (approximately 12 square miles). This would solely rely on natural regeneration to reforest 82 percent of public lands that burned with high severity, an equivalent of approximately 53 square miles.

Cumulatively, alternative B would reforest 23 percent of all lands within the analysis area and 31 percent of lands that burned at high severity (Table 4.4b). It is expected that all private land that was harvested in associated with the Moonlight and Antelope Complex fires would be reforested.

As discussed above (section 3.2.3), natural regeneration within the analysis area is to be expected, however, stocking levels and desired species may be highly variable within site specific locations and within different years post fire. Field experience from many local silviculturists and culturist confirm that sites closest to the surviving seed source have the greatest capacity for natural regeneration and this capacity diminishes the farther the distance from the "edge" or seed source increases. The areas farther from seed sources, especially those large areas that burned at high severity may regenerate, but would take a longer period (potentially decades), and have more variable success in meeting desired stocking standards. Consequently a strategy reliant solely on natural regeneration may or may not establish desired levels of stocking or desired species (particularly pine or rust resistant sugar pine) within acceptable temporal bounds.

Much of the areas that burned under high severity will likely become dominated by brush species. Where natural regeneration does not occur in amounts to re-establish forested conditions, the areas would experience a vegetation type change to brush fields that may persist for decades and potentially more than a century. The cumulative effect of failing to re-establish forested conditions could resonate the longest by delaying the development of mature forest conditions which would otherwise provide multiple benefits such as wildlife habitat and future economic opportunities through forest management. As mentioned above, this risk would be highest in areas that burned with high severity, an equivalent of approximately 53 square miles of public land throughout the analysis area.

Over time, the no action alternative would lead to higher fuel loads from branches and boles of dead and down trees. Over the long term (10+ years), not implementing treatments would result in increased surface fuels. Increased surface fuels would result in increased flame lengths leading to increased mortality of residual live trees and naturally regenerated conifers. It is expected that some fires, both human and lighting caused would continue to escape initial attack in more severe weather conditions over the next 20-30 years. These fires are expected to kill natural regeneration and residual larger trees. Overall, the no action alternative would not reduce potential future surface fuels or predicted fire severity.

Brown et al (2004) in the paper titled “Forest Restoration and Fire: Principles in the context of place” suggests that areas that had historically low-severity fire regimes should have the highest priority for treatment; areas that historically had mixed-severity fire regimes are of intermediate priority, and areas that historically had high-severity fire regimes are of the lowest priority. The Moonlight and Antelope Complex fires area historically had a low severity fire regimes with some mixed-severity (Safford 2008 pers. communication); however, within a three month period in the summer of 2007 over 85 square miles burned under high severity fire. This exemplifies how these events qualify as “uncharacteristic stand replacement fire” within the site specific context of the dry eastside and transition zone northern Sierra Nevada forests and underscores the need for appropriate treatments as described in Frankling and Agee (2003). Passive management strategies, although recommended in general site-unspecific syntheses regarding salvage logging, would maintain an uncharacteristically large amount of dead standing snags and down fuel across a proportionally large portion of the landscape which would persist far outside the range of natural variability for forest types predominate in this area. Consequently, maintenance of these conditions would perpetuate a landscape which may be susceptible to large scale shifts in vegetation type, species composition, and fire regime and deviates from historic ecosystem processes and function.

The Storrie Fire (2000) provides a local, recent, and relevant example of passive management within a dry pine dominated Sierra Nevada forest with a historically low severity fire regime which burned with uncharacteristically high severity. In 2008, several lightning fires re-burned thousands of acres within the foot print of the Storrie fire sustained by dead and down fuels, snags, and brush. This resulted in killing any established natural regeneration as well as trees which had previously survived the Storrie fire, and further compounds the effects of a landscape already deficit in natural regeneration and capacity of live trees available to regenerate the site. In addition, the passive management strategy, effectively in place since 2000, limited fire management suppression and/or containment strategy in 2008. Since brush, standing snags, and downed logs dominated the site, the capacity to get fire personnel into the area and engage the fire was limited due to safety concerns; particularly falling snags. Consequently some of these fires have burned a bulk of the summer, and may continue to burn (in areas) until winter. The cumulative effects on natural regeneration and fire management should be considered under the cumulative effects of the no action alternative project as events within the Storrie Fire provide an interesting perspective of how the no-action alternative may affect management capacity, challenges, and limitations within the Moonlight and Antelope Complex fires.

4.2 Action Alternatives: Alternatives A, C, D, and E

In general, the direct and indirect effects described below would be common to all action alternatives that propose salvage harvesting treatment. The effects of the specific silvicultural prescriptions proposed under the action alternatives are described in the subsequent subsections. However, all treatments involving harvesting using ground-based, skyline, and helicopter logging systems would share similar effects that include the potential for damage to residual trees; incidental removal of snags and live trees; the construction of skid trails, landings, and temporary roads to facilitate logging operations; and the creation of activity-generated slash.

Damage to residual trees and vegetation may occur during harvesting operations including damage to stems, bark scraping, wrenched stems, broken branches, broken tops, and crushed foliage (McIver et al. 2003). These effects are typical in logging operations, but care would be taken to minimize the potential for damage to residual trees. The Forest Service would inspect timber sales during harvesting to ensure that damage to residual trees and vegetation is within reasonable tolerances.

Damage and/or mortality of natural regeneration may occur during harvesting operations, particularly in ground-based harvesting treatments (Donato 2006). Areas where the risk of seedling damage and/or mortality is greatest would be within or near skid trails and landings. The PNF LRMP (1988) soil quality standards provides direction that landings and permanent skid trails should not encompass more than 15 percent of timber stands. Consequently, damage and/or mortality of natural regeneration due to harvesting operations would be limited in size and scale to skid trails dispersed through the stand.

Snags would be removed during salvage harvesting. Incidental removal of snags may occur for operability and safety; however, guidelines set forth in the Sierra Cascade Province Timber Theft and Detection Plan would be used to ensure that operability, safety, and minimum snag densities would be met. The snags to be retained would receive preference in locations where operability and safety are not anticipated to be issues. Snags within falling distances of roads, landings, and heavily used public areas would receive preference for removal.

Existing skid trails, landings, and temporary roads would be used, when available, to facilitate the harvesting and removal of forest products (biomass and sawlogs). Skid trails, landings, and temporary roads could be constructed under all action alternatives to facilitate the removal of forest products when existing infrastructure does not exist. Under all action alternatives, no more than 13 miles of temporary road under alternative A, 12 miles of temporary road under alternative C, and 3 miles of temporary road under alternative D would be constructed, and any temporary roads constructed would be decommissioned after use. Zero miles of temporary road would be constructed under alternative E. All harvest operations including the use and construction of skid trails, landings, and temporary roads would adhere to the standards and guidelines set forth in the timber sale administration handbook (FSH 2409.15 including Region 5 supplements) and the Best Management Practices as delineated in the Water Quality Management for Forest System Lands in California: Best Management Practices (USDA 2000).

Construction of skid trails, landings, and temporary roads would require incidental removal of trees beyond those described for silvicultural purposes. This may include incidental removal of live trees for operability. However, the location and size of skid trails, landings, and temporary roads, and the trees harvested for the construction of such facilities must be approved and agreed upon by the Forest Service. In addition, the PNF LMRP (1988) soil quality standards provides direction that landings and permanent skid trails should not encompass more than 15 percent of timber stands. Live tree removal would be permitted by necessity to allow for such facilities, and would be avoided whenever practicable. Therefore, the removal of trees for operability would be an incidental component of harvesting activities, of minimal size and scale, and highly dispersed, and would have negligible effects on forest vegetation, fuel loading, and fire behavior.

Table 4.3 below displays the direct effects of all alternatives by percentage of acres affected by post-fire harvest activities proposed by the Moonlight and Wheeler Fires Recovery and Restoration Project by level of fire severity.

Table 4.3 Comparison of alternatives: Percent of vegetation burn severity acres affected by the proposed post-fire harvest treatments in the Moonlight and Wheeler project under all alternatives.

	Unclassified due to Satellite Imagery	Low Severity	Moderate Severity		High Severity	Total for all severity classes
		BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total within Analysis Area	258	16679	8401	7770	54539	87647
Percent of Analysis Area	0.3%	19%	10%	9%	62%	100%
Total on NFS lands	0	13600	6983	6531	41294	68408
Alternative A	0%	7%	7%	9%	30%	22%
Alternative B	0%	0%	0%	0%	0%	0%
Alternative C	0%	7%	6%	7%	16%	12%
Alternative D	0%	7%	6%	6%	9%	8%
Alternative E	0%	7%	6%	6%	6%	6%

Alternative A would have the largest direct effect on the analysis area by harvesting 22 percent of public land acres that were burned by the Moonlight and Antelope Complex fires. Of the action alternatives, alternative E would have the least direct effect by harvesting only 6 percent of public land acres. Alternative E represents roadside hazard tree removal only while all other action alternatives contain the same roadside hazard tree removal along with other harvesting of fire-injuredd trees.

4.2.1 Direct and Indirect Effects of Salvage Harvest, Reforestation, & Roadside Hazard Treatments Common to All Action Alternatives

All action alternatives would implement salvage harvest and reforestation treatments designed to meet guidelines as specified under appendix D of the SNFPA ROD (2001 and/or 2004) and comply with the National Forest Management Act (NFMA 1976).

Effects of Salvage Harvest on Forest Vegetation

Salvage harvest treatments are designed to provide for short-term local economic benefit by creating employment opportunities and revenues from the sale of dead merchantable trees. Table 4.4 displays the estimated volumes of sawlog and biomass forest products harvested under each alternative. Each action alternative would provide economic opportunities for forest product removal to varying degrees; alternative A would generate the highest volume of forest products due to the larger acreage treated under that alternative.

Table 4.4: Comparison of Estimated Sawlog and Biomass Volumes produced from Harvest Activities under all alternatives.

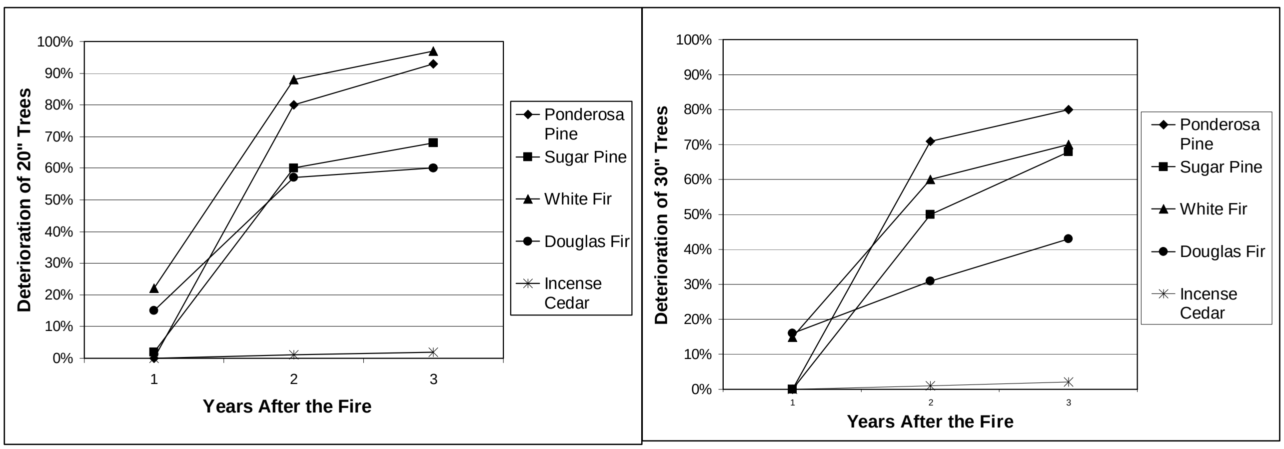
Alt.	Harvest Treatment	Acres	Sawlog Volume (mbf/ac)[1]	Biomass Volume (tons/ac)	Treatment Sawlog Volume (mmbf)	Treatment Biomass Volume (tons)	Project Sawlog Volume (mmbf)	Project Biomass Volume (1000 tons)
A	Helicopter and Skyline salvage harvest: Harvest dead trees > 16 inches DBH	6219	10.0	--	62.2	--	**120.2**	**118**
	Ground-based salvage harvest: Harvest dead trees > 14 inches DBH	4147	10.6	28.4	43.9	117775		
	Ground-based roadside harvest: Harvest dead trees > 10 inches DBH	4389	3.2	--	14.1	--		
B	No Action	--	--	--	--	--	**--**	**--**
C	Ground-based salvage harvest: Harvest dead trees > 14 inches DBH	4147	10.6	28.4	43.9	117774	**58.0**	**118**
	Ground-based roadside harvest: Harvest dead trees > 10 inches DBH	4389	3.2	--	14.1	--		
D	Ground-based salvage harvest: Harvest dead trees > 14 inches DBH	1267	7.2	28.4	9.1	35982	**23.2**	**36**
	Ground-based roadside harvest: Harvest dead trees > 10 inches DBH	4389	3.2	--	14.1	--		
E	Ground-based roadside harvest: Harvest dead trees > 10 inches DBH	4389	3.2	--	14.1	--	**14.1**	**--**

1 Sawlog volume estimates account for volume deduction based on anticipated deterioration one-year following the fire event per FSH 2409.12 22.31, Region 5 supplement.

The estimated volumes of sawlog and biomass forest products are based on field inventory data and account for volume deduction based on anticipated deterioration one-year following the fire event. Insects (primarily beetles), stain and decay fungi, and weather all act as deterioration agents in fire-killed timber causing losses in volume and value.

Insect activity usually precedes fungal activity and provides a mechanism for introducing fungi that accelerate sapwood deterioration and staining. Fungal decay, once introduced, will deteriorate the sapwood ahead of any insect damage. Decay causes reductions in strength properties of wood, rendering the wood useless from a structural standpoint, and thus decreasing useable log volume. Insects such as ambrosia beetles and roundheaded borers, among others, introduce stain fungi and create boring holes that destroy the visual value and structural integrity of wood. In addition to the deterioration caused by stain, decay, and insects, weather checking also contributes to loss. Weather checking is cracks that form vertically in the wood as the tree dries out. With time, the cracks go deeper into the log. In the portion of the log that is checking, the log is unusable for manufacturing boards.

Figure 4.5 Percent board foot deterioration of 20 inch and 30 inch diameter trees, respectively, based on Lowell et al. (1992) and Kimmey (1955)



By the second year following the fire, most trees have significant sapwood decay and weather checking, culling about 65 percent of the board foot volume, with small trees deteriorating faster than large trees (figure 4.5) (Lowell et al. 1992; Kimmey 1955). After one year following the fire, blue stain in ponderosa and sugar pine is expected to be significant (45 percent of Ponderosa pine volume, 75 percent of sugar pine) (Lowell and Cahill 1996; Lowell et al. 1992). Blue stain seriously affects the lumber grade and value. The window of opportunity for recovering value is therefore short.

A Forest Health and Protection Evaluation performed in fall 2007 (Cluck 2007) confirms that "beetle activity and the presence of bluestain are already evident within the Antelope Complex and will be evident in most severely fire-injured and fire-killed trees in the Moonlight fire by the end of next summer (2008). Bluestain fungi do not contribute to volume deterioration, but does affect the value of the wood due to the visual defect caused by staining of the sapwood. Sapwood decay will become significant during the second year post-fire causing significant degrade, volume deterioration, and additional economic value loss." Failure to salvage harvest dead trees within one to two years of the fire event may result in rapidly diminished wood value (Lowell and Parry 2007), and which would further reduce contributions to the local and regional area economy.

Tables 4.6 and 4.7 display the predicted effects of salvage harvest treatments and subsequent reforestation treatments on stand structure for all action alternatives by prescription. Within treatment areas, all dead trees of merchantable size would be harvested with the exception of snag retention prescriptions in Riparian Habitat Conservation Areas (RHCAs) and snag retention areas. Within RHCAs, generally four to six of the largest snags per acre would be retained, preferably within falling distance of the channel where available, to provide for large down woody debris recruitment to best meet riparian management objectives. Within ground-based salvage harvesting treatments, snag retention in RHCAs would be most preferable and efficient within equipment exclusion zones where snags would be within reasonable falling distance of the channel for large woody debris recruitment and harvesting safety issues would be minimized due to equipment exclusion. Within snag retention areas, no salvage harvesting would occur; thereby retaining, the entire suite of small to large sized snags which would enhance structural diversity and break up continuity of treatment units.

Table 4.6 Predicted effects of treatment prescriptions on stand structure (Site class V) for action alternatives A, C, and D.

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Basal Area
	Total	0-10"	10-16"	16-30"	>30"	Total	0-10"	10-16"	16-30"	>30"	
Alternative A: Helicopter & Skyline Salvage Harvest-- Harvest Trees > 16 inches DBH											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Harvest	--	--	--	--	--	15.6	0.0	0.0	13.6	2.0	--
Post	9.6	0.0	7.9	1.5	0.2	272.1	223.6	48.5	0.0	0.0	12
10 years	9.4	0.0	5.8	3.4	0.2	127.7	98.6	29.1	0.0	0.0	16
20 years	101.0	91.7	2.4	6.1	0.4	14.5	4.3	10.2	0.0	0.0	22
30 years	100.1	90.9	0.1	8.6	0.4	1.1	0.8	0.2	0.0	0.0	30
Alternative A: Helicopter & Skyline Salvage Harvest within RHCA's -- Harvest Trees > 16 inches DBH, Retain 4 - 6 Snags per Acre											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Harvest	--	--	--	--	--	12.0	0.0	0.0	10.6	1.4	--
Post	9.6	0.0	7.9	1.5	0.2	275.7	223.6	48.5	3.0	0.6	12
10 years	9.4	0.0	5.8	3.4	0.2	128.7	98.6	29.1	0.7	0.3	16
20 years	101.0	91.7	2.4	6.1	0.4	15.2	4.3	10.2	0.5	0.2	22
30 years	100.1	90.9	0.1	8.6	0.4	1.6	0.8	0.2	0.4	0.2	30
Alternatives A, C, and D: Ground-based Salvage Harvest -- Harvest Trees > 14 inches DBH, Biomass Harvest or Site Prep Trees less than 14 inches DBH											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Harvest	--	--	--	--	--	103.3	39.2	48.5	13.6	2.0	--
Post	9.6	0.0	7.9	1.5	0.2	184.4	184.4	0.0	0.0	0.0	12
10 years	9.4	0.0	5.8	3.4	0.2	77.5	77.3	0.2	0.0	0.0	16
20 years	101.0	91.7	2.4	6.1	0.4	1.3	1.0	0.3	0.0	0.0	22
30 years	100.1	90.9	0.1	8.6	0.4	1.0	0.8	0.1	0.0	0.0	30
Alternatives A, C, and D: Ground-based Salvage Harvest within RHCA's -- Harvest Trees > 14 inches DBH, Biomass Harvest or Site Prep Trees less than 14 inches DBH; Retain 4 - 6 Snags per acre											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Basal Area
	Total	0-10"	10-16"	16-30"	>30"	Total	0-10"	10-16"	16-30"	>30"	
Harvest	--	--	--	--	--	99.3	39.2	48.0	10.6	1.4	--
Post	9.6	0.0	7.9	1.5	0.2	188.4	184.4	0.5	3.0	0.6	12
10 years	9.4	0.0	5.8	3.4	0.2	78.5	77.3	0.2	0.7	0.3	16
20 years	101.0	91.7	2.4	6.1	0.4	2.1	1.0	0.3	0.5	0.2	22
30 years	100.1	90.9	0.1	8.6	0.4	1.5	0.8	0.1	0.4	0.2	30
All Action Alternatives: Snag Retention Areas											
Existing	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
Harvest	--	--	--	--	--	--	--	--	--	--	--
Post	9.6	0.0	7.9	1.5	0.2	287.7	223.6	48.5	13.6	2.0	12
10 years	9.4	0.0	5.8	3.4	0.2	139.3	98.6	29.1	9.9	1.8	16
20 years	101.0	91.7	2.4	6.2	0.4	22.2	4.3	10.2	6.1	1.5	22
30 years	100.1	90.9	0.1	8.2	0.4	4.5	0.0	0.4	2.9	1.3	30
Note: For low sites, all stands for helicopter, skyline, and ground-based systems were averaged.											

Table 4.7 Predicted effects of treatment prescriptions on stand structure (Site classes III & IV) for all action alternatives.

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Basal Area
	Total	0-10”	10-16”	16-30”	>30”	Total	0-10”	10-16”	16-30”	>30”	
Alternative A: Helicopter and Skyline Salvage Harvest–Harvest Trees > 16 inches DBH											
Existing	5.5	4.2	0.6	0.5	0.2	452.1	355.8	49.1	41.9	5.3	4
Harvest	--	--	--	--	--	47.2	--	--	41.9	5.3	
Post	5.5	4.2	0.6	0.5	0.2	404.9	355.8	49.1	0.0	0.0	4
10 years	4.8	2.7	1.4	0.4	0.3	174.2	146.8	27.4	0.0	0.0	5
20 years	96.4	93.6	2.1	0.5	0.3	20.6	11.8	8.8	0.0	0.0	9
30 years	95.2	92.3	0.9	1.7	0.4	1.0	0.8	0.1	0.0	0.0	18
Alternative A: Helicopter and Skyline Salvage Harvest within RHCA’s – Harvest Trees > 16 inches DBH, Retain 4 – 6 Snags per Acre											
Existing	5.5	4.2	0.6	0.5	0.2	452.1	355.8	49.1	41.9	5.3	4
Harvest	--	--	--	--	--	43.2	--	--	38.4	4.7	
Post	5.5	4.2	0.6	0.5	0.2	408.9	355.8	49.1	3.4	0.6	4
10 years	4.8	2.7	1.4	0.4	0.3	175.5	146.8	27.4	1.1	0.2	5
20 years	96.4	93.6	2.1	0.5	0.3	21.4	11.8	8.8	0.8	0.1	9
30 years	95.2	92.3	0.9	1.7	0.4	1.5	0.8	0.1	0.6	0.0	18
Alternative A, C, and D: Ground-based Salvage Harvest – Harvest Trees > 14 inches DBH, Biomass Harvest or Site Prep Trees less than 14 inches DBH											
Existing	16.5	0.0	7.7	7.0	1.8	415.1	352.5	32.7	24.0	6.0	43
Harvest	--	--	--	--	--	150.1	87.4	32.7	24.0	6.0	
Post	16.5	0.0	7.7	7.0	1.8	265.0	265.0	0.0	0.0	0.0	43
10 years	16.3	0.0	6.5	7.3	2.4	108.0	107.1	0.6	0.3	0.0	46
20 years	96.0	80.4	5.1	7.9	2.6	9.1	7.9	0.8	0.4	0.0	50
30 years	103.6	88.6	3.6	8.6	2.9	2.0	0.7	0.8	0.4	0.0	60
Alternative A, C, and D: Ground-based Salvage Harvest within RHCA’s – Harvest Trees > 14 inches DBH, Biomass Harvest or Site Prep Trees less than 14 inches DBH; Retain 4 – 6 Snags per acre											
Existing	16.5	0.0	7.7	7.0	1.8	415.1	352.5	32.7	24.0	6.0	43
Harvest	--	--	--	--	--	125.7	71.6	27.9	21.2	5.0	
Post	16.5	0.0	7.7	7.0	1.8	289.4	280.9	4.8	2.8	1.0	43

Time Frame	Live Trees Per Acre by Diameter Class					Dead Trees Per Acre by Diameter Class					Basal Area
	Total	0-10"	10-16"	16-30"	>30"	Total	0-10"	10-16"	16-30"	>30"	
10 years	16.3	0.0	6.5	7.3	2.4	112.6	109.9	1.1	1.2	0.4	46
20 years	96.0	80.4	5.1	7.9	2.6	10.3	7.9	1.0	1.1	0.2	50
30 years	103.6	88.6	3.6	8.6	2.9	2.6	0.7	0.8	1.0	0.1	60
All Action Alternatives: Snag Retention Areas											
Existing	11.6	2.1	4.1	3.8	1.0	434.7	354.1	40.9	32.9	5.7	23
Harvest	--	--	--	--	--	--	--	--	--	--	
Post	11.6	2.1	4.1	3.8	1.0	434.7	354.1	40.9	32.9	5.7	23
10 years	10.4	1.5	3.8	3.7	1.3	200.4	148.4	23.5	22.7	5.0	24
20 years	10.0	1.0	3.6	3.9	1.4	40.1	13.2	8.0	14.2	4.4	26
30 years	9.6	0.8	2.2	4.9	1.5	10.8	0.1	0.6	6.2	3.8	28

Direct and indirect effects under all action alternatives would include the removal of trees greater than 14 to 16 inches in diameter within treatment units. In areas proposed for ground-based logging, trees less than 14 inches in diameter would be removed as biomass product or treated through site preparation; trees less than 6 inches in diameter would likely be crushed, felled, or pushed over, although some may remain standing. The net effect would be a reduction in standing snags and a decrease in recruitment of large down woody debris contributing to a simplification of forest structure within treatment units with the exception of the snag retention areas and large snag retention within RHCAs where all or portions of such structure would be maintained. This is consistent with effects as noted in McIver and Ottomar (2007).

The emphasis of the silvicultural prescriptions for salvage harvest treatments is economic recovery through harvest of fire-killed (dead) trees. As discussed above under Section 3.2.4 Design Criteria and Section 4.2.1 Direct and Indirect Effects Common to All Action Alternatives, incidental removal of live trees to facilitate timber harvesting operations would occur, however, this is expected to be minimal in scale and highly dispersed. Since CWHR classification is primarily dependent on live forest vegetation, salvage harvest treatments would not change CWHR vegetation type, size class, or density.

Effects of Reforestation on Forest Vegetation

As discussed above (section 3.2), natural regeneration within the analysis area is to be expected, however, may be highly variable within site specific locations and within different years post fire. Field experience from many local silviculturists and culturist confirm that site closest to the surviving seed source have the greatest capacity for natural regeneration, particularly the desired species such as pine, and this capacity diminishes the farther the distance from the "edge" or seed source increases. The areas farther from seed sources, especially those large areas that burned at high severity may regenerate, but would take a longer period (potentially decades), and have more variable success in meeting desired stocking standards. Consequently a strategy reliant solely on natural regeneration most likely would not establish desired levels of stocking or desired species within acceptable temporal bounds.

Considering this and the fact that naturally occurring regeneration may also be damaged by salvage harvest operations (Donato 2006) proposed under the action alternatives, all action alternatives include reforestation utilizing a wide spaced low density cluster planting design. The cluster planting is designed to establish minimum stocking of desired species appropriate for the native ecological forest type at a density high enough to meet desired stocking levels, but low enough to create desired open canopied forested stands that compliment any natural regeneration that may occur. The cluster arrangement is also designed to be congruent with variable seedling survival to produce a planting that mimics the heterogeneity and pattern of a naturally occurring open canopied forest rather than a high density squared spaced plantation or "tree farm". Desired species appropriate for the native ecological forest type would be planted such as ponderosa pine, Jeffrey pine, Douglas-fir, rust resistant sugar pine, incense cedar, and white and red fir. Species mixes would be dependent on elevation, aspect, and seed availability. Table 4.8 displays the projected height and diameter growth for planted seedlings.

Table 4.8 Projected height and diameter growth for planted seedlings

Time Frame	Site V			Site III & IV		
	Ht (ft)	DBH (in)	Canopy Cover (%)	Ht (ft)	DBH (in)	Canopy Cover (%)
Existing	0	0.0	0%	0	0.0	0%
Harvest	--	--	--	--	--	--
Post	Plant post-harvest			Plant post-harvest		
10 years	4	0.2	0%	4	0.2	0%
20 years	9	1.7	1%	10	2.1	1%
30 years	15	3.5	3%	18	4.7	6%
40 years	25	6.9	13%	28	7.8	17%
50 years	36	9.7	25%	38	10.3	29%

Projected height and diameter growth displayed in table 4.8 shows that within 40 to 50 years, cluster plantings are projected to develop into open canopied forested stands characterized by CWHR size class 3S and 3P stands. While manual release to reduce shrub competition would occur around the immediate proximity of the planted seedlings, these stands are expected to have a notable shrub component in the understory and in areas of low survival; however select microsites would likely support larger trees with reduced shrub understory. This projected stand development is on par with similar post-fire salvage and reforestation projects within the analysis area, such as those plantations established after the Elephant fire (1981), the Big Burn fires (1966, 1972), and the Morton Creek fire (1959). These activities would promote re-establishment of forested conditions within the project area.

Action alternatives do not include treatment of stumps with borax to limit the spread of Annosus Root Disease (*Heterobasidion annosum*). Annosum has been documented in both pine and fir stands on the Mt. Hough Ranger District, and on the neighboring Lassen National Forest to the north of the analysis area (Woodruff 2005). There is potential for new infection in any harvest area because airborne spores that colonize freshly cut stumps and root to root contact spread the disease. Infection centers would create localized pockets of dead trees.

In areas where stumps were left untreated on the eastside of the Plumas National Forest, infection rates ranged from 12 to 34 percent (Kliejunas 1989) and past studies on the Shasta Trinity and Modoc National Forests have found between 3 and 17 percent of untreated 18 to 22 inch ponderosa pine stumps and between 8 and 35 percent of 22 to 26 inch ponderosa pine stumps" (Woodruff 2005); however, these studies were from "live" timber harvests. Kliejunas, Allison, and Otrosina (2006) found in their study that none of the dead pine stumps were infected by annosum; however, they caution that fire-killed trees determined by off-color, yellow, or brown needles may still contain live wood tissue which may be colonized. Since most of the areas of high severity have completely incinerated crowns and/or completely killed cambiums, the risk of infection may be reduced since stumps of fire salvaged trees may contain higher levels of dead tissue; particularly since trees would be harvested more than a year after the fire.

Woodruff (2005) suggests that stand-replacing wildfire may reduce or eliminate the occurrence of the disease in affected areas due to the prolonged time the roots of newly established seedlings take to interact with roots of infected stumps. The wide-spaced planting design would limit the spread of the disease by root to root contact from seedling to seedling or seedling to stump. In addition, since strains of annosum root disease are species specific, proposed mix species plantation would further limit the effects of this disease on newly established plantations. In fact, incidental occurrence through the analysis area may contribute to landscape structure and diversity by creating pockets of variable growth and/or survival.

Effects of Salvage Harvest and Reforestation on Fuels, Fire Behavior, and Air Quality

Under alternative A, removal of dead trees would be completed via helicopter, skyline, and ground based harvest systems within primarily high and moderate fire severity areas. Within RHCAs, an average of approximately four snags per acre would be retained. Tree boles would be cut down and removed by helicopter while tops and limbs would be lopped and scattered. Residual standing dead trees or scorched trees that die in the future would begin to decay and fall over time. The limbs and boles from these fallen trees would accumulate as surface fuels. Within 10 years of treatment, surface fuels up to 12 inches in diameter are projected to be 13 tons per acre. Within 30 years, surface fuels up to 12 inches in diameter are projected to average ~15 tons per acre due to dead trees falling over. This amount is slightly lower than the no action alternative as the tree boles which would contribute to surface fuel loading will have been removed. This loading would remain relatively stable over time as decayed surface fuels are replaced by future dead trees that fall over. Within RHCAs, predicted fuel loading for materials up to 12 inches in diameter is similar than outside of RHCAs (table 4.9). The primary difference between RHCAs and non-RHCAs for the helicopter treatment is in the surface fuels greater than 12 inches in diameter. These fuels are directly contributed by higher numbers of snags retained in RHCAs which fall over.

Within ground-based harvest units, trees less than 14 inches DBH would be removed as biomass product (whole tree harvested). This would result in less surface fuel deposition then the helicopter harvest method, particularly for surface fuel material greater than 6 inches in diameter (table 4.9). Surface fuel loads up to 6 inches in diameter are comparable to those created by helicopter harvest as well as natural shedding of branches/limbs in the no action alternative. Within 30 years, surface fuels up to 12 inches in diameter are projected to average 1 to 4 tons per acre, with higher amounts located in RHCAs and snag retention areas, due to retained dead trees falling over. This amount is substantially lower than the no action alternative as the tree boles which would have contributed to surface fuel loading will have been removed. The primary difference between RHCAs and non-RHCAs for the tractor treatment is in the surface fuels greater than 12 inches in diameter. These fuels are directly contributed by higher numbers of snags retained in RHCAs which fall over. This loading would remain relatively stable over time as decayed surface fuels are replaced by future dead trees that fall over.

Shrub fuels would be established within 10 years. Based on shrub regeneration observed in past fires that have been salvaged in this area (Stream fire 2001), shrub regeneration is typically patchy, and will be slightly higher than in No Action areas but will remain less than 50 percent cover, and dominated by either tobacco brush (*Ceanothus velutinus*), white thorn (*C. cordulatus*), and green leaf manzanita (*A. patula*).

Development of forest vegetation, specifically trees, are described above under section 4.2.2. Ladder and crown fuels would develop slowly over time following establishment of cluster plantations; however, due to the wide-spacing of these plantations, continuous interlocking canopies of young trees would not occur.

Predicted Fire Behavior and Effects

With helicopter and skyline harvesting, predicted flame lengths and percent of basal area killed are displayed in table 4.9. Under helicopter harvesting, flame lengths exceed 4 feet and are projected to exceed 6 feet within 30 years. These increased flame lengths are a direct result of fire burning in dead and down logs, branches, and shrubs. Fires burning in stands under 90th percentile weather conditions (table 3.2) under this alternative are expected to result in mortality exceeding 80 percent of live basal area, including residual trees and particularly in naturally established and planted conifers. Under the action alternatives, this general trend in high flame lengths (>6 feet) and corresponding high tree mortalily (>80 percent) is expected to continue at least 20-30 years into the future.

Table 4.9 Predicted surface fuel, flame length, and basal area mortality for treatments proposed under action alternatives.

		1 to 3 Inch Diameter Surface Fuels	3 to 6 Inch Diameter Surface Fuels	6 to 12 Inch Diameter Surface Fuels	Greater than 12 Inch Diameter Surface Fuels	All Surface Fuels	Predicted Flame length	Predicted Percent Basal Area mortality
Treatment Type	**Time Frame**	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***(Feet)***	***%***

		1 to 3 Inch Diameter Surface Fuels	3 to 6 Inch Diameter Surface Fuels	6 to 12 Inch Diameter Surface Fuels	Greater than 12 Inch Diameter Surface Fuels	All Surface Fuels	Predicted Flame length	Predicted Percent Basal Area mortality
Treatment Type	**Time Frame**	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***Tons per Acre***	***(Feet)***	***%***
All	Existing	2.6	2.8	3.2	0.5	9.1	4.0	58.3
Helicopter and Skyline Harvest	Post-Harvest	2.6	2.8	3.3	1.2	9.9	6.1	88.9
Helicopter and Skyline Harvest	10 years	2.7	4.0	6.3	4.4	17.4	6.3	87.3
Helicopter and Skyline Harvest	20 years	2.4	4.6	8.6	5.6	21.2	6.6	84.6
Helicopter and Skyline Harvest	30 years	2.2	4.1	8.5	5.9	20.6	6.9	84.7
Helicopter & Skyline Harvest-RHCA	Post-Harvest	2.6	2.8	3.2	4.3	13.0	6.1	88.9
Helicopter & Skyline Harvest-RHCA	10 years	2.7	3.9	5.8	7.6	20.0	6.3	87.3
Helicopter & Skyline Harvest-RHCA	20 years	2.4	4.5	8.0	10.6	25.5	6.6	84.6
Helicopter & Skyline Harvest-RHCA	30 years	2.2	4.0	8.1	10.8	25.0	6.9	84.7
Tractor Harvest	Post-Harvest	2.6	2.8	3.3	1.1	9.9	6.1	88.9
Tractor Harvest	10 years	2.4	2.9	2.9	1.0	9.1	6.3	87.3
Tractor Harvest	20 years	2.2	2.8	2.6	0.9	8.4	6.6	84.6
Tractor Harvest	30 years	1.9	2.5	2.3	0.8	7.5	6.9	84.7
Tractor Harvest-RHCA	Post-Harvest	2.6	2.9	3.5	1.3	10.4	6.1	88.9
Tractor Harvest-RHCA	10 years	2.5	3.4	5.0	4.1	14.9	6.3	87.3
Tractor Harvest-RHCA	20 years	2.2	3.4	4.8	4.5	15.0	6.6	84.6
Tractor Harvest-RHCA	30 years	2.0	3.0	4.4	4.4	13.8	6.9	84.7
Snag Retention Areas	Post-Harvest	2.6	2.8	3.2	0.5	9.0	4.0	58.3
Snag Retention Areas	10 years	2.8	4.3	7.0	4.9	19.0	7.7	93.2
Snag Retention Areas	20 years	2.6	4.9	10.4	10.0	27.9	10.7	95.3
Snag Retention Areas	30 years	2.4	4.3	10.3	12.4	29.5	10.9	94.3

With tractor harvesting, predicted flame lengths and percent of basal area killed are displayed in table 4.9. Under alternatives C, D, and E flame lengths exceed 4 feet and are projected to exceed 6 feet within 30 years. These increased flame lengths are a direct result of fire burning in dead and down logs, branches, and shrubs. Fires burning in stands under 90th percentile weather conditions under these alternatives are expected to result in mortality exceeding 80 percent of live basal area, including residual trees and particularly in natural and planted conifers. Under the action alternatives, this general trend in high flame lengths (>6 feet) and corresponding high tree mortalily (>80 percent) is expected to continue at least 20-30 years into the future.

Smoke from pile burning & vehicle dust emissions

Emissions for all alternatives are displayed in table 4.10. Under alternatives A, C, D, and E pile burning would be concentrated in helicopter and/or tractor harvest landings and along the roadside corridor. Due to the dispersed nature of the burn piles, the near complete combustion of piled material, and the control over ignition times to favor good smoke dispersion, it is not anticipated that pile burning would substantially impact the local communities. Smoke would be blown to the northeast towards Susanville and Janesville by typically southwest winds during the day. At night, smoke from burn piles in the project area would move down the Indian Creek drainage towards the community of Genesee Valley or down Moonlight and Lights Creek towards North Arm/Indian Valley. All burning would be completed under approved burn and smoke management plans. Piles would be constructed to minimize mixing of soil and burned under weather conditions that would allow efficient combustion. Predicted emissions from smoke production would be spread out over a period of three to five years depending on the implementation timelines of salvage harvest treatments and the occurrence of favorable burning conditions.

Table 4.10 Predicted emissions for all piles burned in the analysis area.

Alternative	Total PM_{10} Emissions (tons)	Total $PM_{2.5}$ Emissions (tons)	Total PM CH_4 Emissions (tons)	Total CO Emissions (tons)	Total PM CO_2 Emissions (tons)	Total NMHC Emissions (tons)	Total VOC Emissions (tons)	Total Vehicle Dust Emissions[a] (tons)
Alternative A	324	292	283	2884	54724	198	410	567
Alternative B (no action)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Alternative C	218	196	190	1938	36771	133	275	328
Alternative D	169	152	147	1500	28459	103	213	217
Alternative E	147	132	128	1308	24822	90	186	169

Notes:

PM = particulate matter, CH_4 = methane, CO_2 = carbon dioxide, NMHC = nonmethyl hydrocarbon, VOC = volatile organic compound

a. Vehicle Emissions = emissions (dust) from vehicles used during implementation. Assumes an 80 percent reduction in emissions from road surfaces (1.2 pounds per vehicle mile before watering) through implementation of standard road watering procedures. Vehicle miles assumes 20-mile average round trip on dirt roads per load; number of trips assumes 4 loads per acre treated

Dust emissions (table 4.10) would be spread out during the mechanical treatment implementation period of approximately three to five years. Dust would be mitigated by road watering and other standard management practices described in contracts (sections T-806 and B-5.3). No known serpentine based soils are in the project area would be disturbed by project implementation activities. Alternative E would have the lowest overall dust emissions when compared to action alternative A. Harvesting, biomass removal, and road work would be completed primarily with diesel-powered equipment, including feller bunchers, skidders, tractors, graders, and trucks. This equipment would be inspected to determine equipment (spark arresters, fire extinguishers, and firefighting equipment) compliance with fire safety standards. The condition of emissions control systems of various pieces of equipment would vary by age, maintenance, manufacturer, and past use.

Effects of Roadside Hazard Removal on Forest Vegetation

Roadside hazard tree removal is common to all action alternatives and is designed to insure safe travel routes on Forest Service System Roads for public, special use permitees, private landowners, employees, contractors, recreational users, and any visitor who drives these roads to access private and/or National Forest Lands. The purpose is to remove hazardous trees with structural defects likely to cause failure in all or part of the tree, which may fall and hit the road prism within the next three years in a timely, efficient, and cost-effective manner.

In the context of recreation resource management, hazard is some exposure to the possibility of loss or harm. With reference to trees, it is the recognized potential that a tree or tree part will fail and cause injury or damage by striking a target. All standing trees, alive or dead, within areas occupied by people, structures, and property present some level of hazard. Potential for failure by itself does not constitute a hazard. Hazard exists when a tree of sufficient size and mass to cause injury or damage is within striking distance of any object of value (people, property, etc.) Hazard increases with increasing tree defect, potential for failure, potential for damage, and target value. Management actions are taken to mitigate the hazard when risks are unacceptable. It is the responsibility of the land manager to discover and correct any unreasonably dangerous conditions to minimize the potential for injury to invited users or damage to their personal property.

The Plumas National Forest Roadside /Facility Hazard Tree Abatement Action Plan (2008) and corresponding removal guidelines provides direction on hazard tree identification and abatement, however, do not include identification criteria for recently affected fire-injured trees. It is reasonably anticipated that tree mortality associated with fire-injury may occur for years subsequent to the Moonlight Fire. Fire-injured tree marking guidelines for this project were developed by the Pacific Southwest Region Forest Health Protection Staff, based upon tree mortality models from the latest scientific research by Fire Sciences Laboratory at the Rocky Mountain Research Station (Hood et al. 2007) and Pacific Southwest Region Forest Health Protection Staff. These guidelines are based on tree data collected on over 5,000 trees, which is the largest database available of fire-injured trees in California. These marking guidelines incorporate 4 year post-fire data from Smith and Cluck (2007), as well as research from "Predicting post fire mortality of seven western conifers (Ryan and Reinhardt, 1988), and field examination and recommendations by Danny Cluck, Forest Health Protection staff entomologist (July 27, 2007).

Identification and designation of hazard trees is consistent with and follows the Plumas National Forest Roadside/Facility Hazard Tree Abatement Action Plan (2008). The cambium sampling and stratified random sampling methods used in the study (Hood et al 2007) is consistent with scientific literature on monitoring fire-injured trees and ensures that data were collected from a wide range of tree injuries and sizes.

The Hood et al. (2007) pine model using percent crown volume scorched and diameter at breast height (DBH), developed for the purpose of comparing with other studies for trees equal to 50 cm DBH, was very similar to the model developed by Stephens and Finney (2002). The Hood et al. (2007) models predict increasing probabilities of mortality with increasing DBH for pines. This is similar to results in McHugh and Kolb (2003) for ponderosa pine models developed using wildfire alone and prescribed and wildfire combined data sets, but contrary to the prescribed fire models reported in Stephens and Finney (2002) and McHugh and Kolb (2003). Above 75 percent crown volume scorched, the Hood et al. (2007) model predicted slightly higher probabilities of mortality. This discrepancy between predicted probabilities of mortality increases greatly as trees get larger. The lower predicted probabilities in the Stephens and Finney (2002) models compared to the Hood et al. (2007) models may be attributed to the small overlap between the data sets (average of 62.6 cm DBH for Hood et al. (2007) versus 26.3 cm DBH for Stephens and Finney (2002)). Mr. Finney (pers. comm. to Mike Landram, Regional Silviculturist, Pacific Southwest Region, Vallejo, CA) indicated that their paper was intended to relate prescribed fire characteristics to mortality of the mixed conifer species for use in achieving prescribed fire objectives, *not* to provide marking guidelines for post-fire measurements. In addition, the probability equations presented in the paper use predictor variables based on data obtained pre-fire. These predictor variables are not available in post-wildfire situations and make the applicability of this paper to modify or improve current post-fire marking guidelines unsound. Most often, the objective of a prescribed fire is to limit mortality of the overstory while reducing fuel loadings and ingrowth of smaller trees. Therefore, a data set from a prescribed burn likely does not contain many larger, overstory trees with high levels of crown and cambium kill. The differences in tree size and fire type could account for the different effects of DBH when predicting mortality.

Odion and Hanson (2006) studied a 210 fire-injured tree database from the McNally Fire (2002). The Odion and Hanson data is pooled into 2 size classes (Odion and Hanson 2006): basically trees that are between 10-20 inches DBH and those above 20 inches DBH. A further breakdown of size classes above 20” DBH (or subsequent mortality by size classes) is not provided so it is not possible to determine how much overlap exists between the Odion and Hanson (2006) data set and the Hood et al. (2007) data set. In addition, Odion and Hanson (2006) only monitored trees for two years post-fire, whereas the project marking guidelines for pines are based on 4 years of post-fire data. McHugh and Kolb (2003) found distinct differences in tree mortality in their study trees 3 years post-fire from 3 different fires. Other authors (Ryan et al. 1988; Ryan and Reinhardt 1988; Ryan and Amman 1996; Sackett and Haase 1998) have noted additional mortality to occur, in a variety of conifer species and size classes, over much longer periods than the two-year post-fire monitoring by Odion and Hanson (2006).

The spirit of these marking guidelines is to remove those trees likely to fail to abate potential hazards to forest visitors and improve safety and access to private and public lands, while retaining those trees that do not meet the guidelines to provide continuous forest cover that maintains high visual quality and enhances ecological and recreational values. This balance would provide healthy forest cover in a natural-appearing setting, which functionally and aesthetically satisfies visitors while providing for safety and access to the area.

Within roadside treatment areas, all trees of merchantable size that meet the marking criteria of the Plumas National Forest Roadside / Facility Hazard Tree Abatement Action Plan (2008) and the Salvage Marking Guidelines for the Lassen, Plumas, Modoc, and Tahoe National Forests (Cluck 2007) would be harvested.

The roadside hazard tree removal as implemented through the marking guidelines would result in reduced snags and downed logs within striking distance of roads and facilities. It would also reduce the amount of fire-injured trees that would likely die resulting in reduced snag recruitment within striking distance of roads and facilities. The purpose of the marking guidelines is to remove those trees that would be likely to die and fail to abate potential hazards to forest visitors and improve safety and access, while retaining those trees that do not meet the removal guidelines to provide continuous forest cover.

Many factors contribute to the rate at which snags may fall. Among these are tree size, species, cause of mortality, occurrence of severe weather events, soils, and climate. The Moonlight fire combines many of the factors that have been reported to cause higher and faster fall rates of snags.

The Moonlight fire burned in the transition zone between the westside and eastside forests of the Sierra Nevada. There are a mix of species that occur in this transition zone, including ponderosa pine, sugar pine, Jeffery pine, white fir, red fir, Douglas-fir, and incense cedar. The two most abundant species that burned under high severity in the Moonlight fire were ponderosa pine and white fir. Ponderosa pine has been reported to have a faster fall rate than white fir (Landram et al. 2002, Raphael and Morrison 1987). However, Cluck (FHM Report: NE07-08) in his report to the District Ranger of the Mt. Hough Ranger District addressing potential bark beetle mortality within the Moonlight and Antelope Complex fires stated that fire-injured white fir, 8-inch to 24-inch DBH, have been reported to fall in as little as three years post-fire with rate of fall dramatically increasing after the fourth year (FHM Report: SPR-07-05). In a 22 year study of ponderosa pine snags, Dahm (1949) reported that 50 percent of snags fell within 10 years and 78 percent after 22 years.

The diameter of the snag contributes to its fall rate. Most studies cited here found that the greater the snag diameter the longer it would stand, especially for snags greater than 16-inches DBH due to the larger amount of wood to decay. The Dahm (1949) study reported that larger snags (averaging 26-inches DBH) stood longer than smaller snags (averaging 22-inches DBH). Although the average size of the “smaller” snag was 22-inches DBH, a half-life of 10 years was still reported in this study.

The cause of mortality has been shown to be a factor in snag fall rates. Sixty-two percent of all acres in the Moonlight and Antelope Complex fires burned at high severity. Based on 30 years of local experience and observation from district staff of snagfall in the Will (1979) and Elephant (1982) fires, it is noted that fire-killed stands tended to have higher and faster rates of snagfall than the "natural background mortality" snagfall. These local observations are generally consistent with trends described in the Russell (2006) study showing that fire-killed snags have lower half lives and that snags fell much faster in areas that had been logged. Also, a Chambers and Mast study (2005) suggests differences in burned and unburned snag fall rates concluding that burned snags fell faster and at a higher rate than unburned snags. Therefore, the assumption of district staff is reasonable and reflective of local conditions. Furthermore, the Russell (2006) study showed that ponderosa pine and Douglas-fir, two of the more common occurring species killed in the Moonlight fire, have a half-life of 7 – 16 years depending on whether the area had been salvaged logged or not with ponderosa pine predicted to fall sooner than Douglas-fir.

The soils in the Moonlight fire perimeter consist mostly of decomposed granite. This is a soil type made up of weathered granite and is considered to be a loamy sand. Many physical changes take place to soils post-fire with the effects to soils worsening with higher fire severity. The magnitude of change in the physical properties of the soil partly depends on the amount of organic matter destroyed (DeBano 1979). At temperatures of 500 degrees Fahrenheit (F), organic matter can ignite, and at temperatures above 390 degrees F, the destructive distillation of organic substances occurs (Hosking 1938). None of the units surveyed in the aftermath of the Moonlight fire has any appreciable fine organics left. Even though below temperatures of 390 degrees F organic matter is usually not destroyed, it can be distilled from one location to another one deeper in the soil, which can significantly alter the wettability of the soil (Savage 1974). Even brush fires can decrease infiltration by producing a water-repellent layer, which is frequently found in burned areas parallel to the soil surface (DeBano et al. 1967). The soil at or near the surface may be wettable, but a layer below repels water. Infiltration is impeded by this water repellant layer, which for the purposes of this discussion, adds up to increased erosion and debris movement. Decomposed granite is difficult to revegetate because of moisture and Nitrogen limitations. If precipitation rates reach a point of soil saturation due to infiltration impediment caused by the water repellant layer, there is a chance of increased erosion and debris movement on the burned area of the Moonlight fire. This, in turn, may cause a higher and faster rate of snag fall, especially in conjunction with severe weather events, such as high winds (FHM Report: NE07-08).

The Moonlight fire combines many attributes that have been reported to cause a higher and faster rate of snagfall. As reported in Raphael and Morrison (1987), fire-killed snags tend to fall at higher rates than beetle-killed snags, but as reported in FHM Report: NE07-08, beetle activity is expected to occur on fire-killed trees in the Moonlight fire, which will further weaken the structure of the tree and possible cause mortality to trees that were weakened by the fire. The amount of insect activity and the resulting tree mortality depends on factors such as the timing of the fire, level of fire injury, level of insect activity in the area prior to the fire, and precipitation. The Boulder fire (2006) burned very near to both the Moonlight and Antelope Complex fires. Insect activity was occurring on the Boulder fire prior to the Moonlight fire, which could result in an increase of beetle activity on the Moonlight fire. This, in conjunction with the high level of fire injury and drought, could increase the rate of snagfall (Keen 1955). Keen studied the fall rates of bark beetle-killed ponderosa pine in northern California for 30 years. The snags in his study had an average diameter of 24-inches DBH and all snags combine were reported to have a half life of 7 years. Snags fell at a rapid rate in year 5 and continued until year 15. After 10 years, 40% were still standing and after 25 years 10% were still standing. Snags on loam soils, like soils on the Moonlight fire, were shown to have a half life of 6-7 years. Although the Keen report studied the snag fall rate for bark beetle-killed snags, as mentioned above other studies (Raphael and Morrison 1987) report a higher and faster snag fall rate for fire-killed snags over beetle-killed snags, so with the fire-killed trees also under attack by insects it can be expected that the snagfall rate on the Moonlight fire could be higher and faster than some studies cited.

Based on timber cruise data, approximately 57,666 trees greater than 10 inches dbh were marked for removal across 4,389 acres. This amounts to an average of approximately 13.1 trees per acre marked for removal within the roadside hazard area. The number of trees per acre actually slated for removal, however, would vary greatly depending on severity. That is, roads traveling through low severity areas would have little-to-no trees per acre designated for removal whereas roads traveling through high severity areas may have substantially more trees per acre designated for removal due to the large amount of fire-killed and/or fire-injured trees that are within striking distance of the road. Sixty eight percent of the roads intersect areas of high burn severity, 10 percent intersect areas of moderate burn severity, and 22 percent intersect areas of low severity burn. Consequently, the majority of the roadside project area is, indeed, within high severity burn areas where tree survival rate is little-to-none (Tompkins 2008).

Stand exam data indicates that there are an average of 73 live and dead trees per acre over 10 inches in diameter on Site class V lands (versus up to 97 trees per acre on Sites III and IV). Given the roadside treatment areas were approximately 4,389 acres, a conservative rough estimate is that over 320,000 trees were assessed for removal; roughly 18 percent of the trees assessed were marked for removal. Of the approximately 57,666 trees greater than 10 inches dbh marked for removal, approximately 78% are pole sized and small trees between 10 and 24 inches dbh, 18 percent are medium/large sized trees between 24 and 40 inches dbh, and 4 percent are large trees greater or equal to 40 inches dbh (Tompkins 2008). Consequently, the majority of the trees marked for removal trees are less than 24 inches located primarily within areas of high fire severity where safety along access routes is the primary concern.

These effects are substantiated by past similar post-fire roadside hazard tree removal projects that have occurred on the Mt. Hough Ranger District. Roadside hazard tree removal projects on the Mt. Hough Complex fires (1999), Storrie Fire (2000), and Stream fire (2001) were implemented to provide for public safety along forest roads. Some of these similar projects overlapped with additional salvage proposals that were implemented such as the roadside hazard tree removal project that occurred within the Stream fire, while others did not (roadside hazard tree removal projects associated with the Mt. Hough Complex and Storrie fires. In either case, these projects displayed similar limited and dispersed effects that were restricted to the roadside corridors.

Based on past roadside hazard projects on the Mt. Hough Ranger District, the roadside hazard portion of the project directly reduces the short and long-term risk of injury or death to the public, Forest Service employees, and contractors, and reduces damage to roads or property along traveled routes within the project area. Removal of hazard trees and the subsequent treatment of activity slash effectively meet the desired conditions within the project by mitigating hazards and providing for public safety along roads and facilities. Effective ground cover would be provided to stabilize soils and reduce erosion potential while not exceeding fuel arrangement leading to hazardous fuel conditions.

4.2.2 Cumulative Effects of Action Alternatives (A, C, D, & E)

The cumulative effects of past projects may be characterized by the conditions that currently exist on the landscape. Present and planned future projects demonstrate a shift in land management practices that emphasize values such as public safety, maintenance and enhancement of surviving forest, re-establishment of forested conditions, and economic recovery over values which guided past practices.

Under the action alternatives (A, C, & D), salvage harvest, roadside hazard tree removal, and reforestation treatments would occur; and under alternative E, roadside hazard tree removal and reforestation treatments would occur. Due to the scope and design of the proposed treatments and silvicultural prescriptions, cumulative effects of salvage harvesting treatments would include reductions of fire-killed trees in primarily moderate to high fire severity areas. Cumulative effects in these areas would include a reduction in snags, and a reduction in large woody debris recruitment. Within treatment units, these reductions in snags and large woody debris recruitment would be the most apparent in the larger tree sizes since most of the smaller size trees would remain under helicopter and skyline salvage harvesting. These effects would, in turn, affect fuel loading and potential fire behavior within the treatment units.

In McIver and Starr (2001), the authors explain that “two distinct types of environmental effects occur after a harvest operation: activity effects owing directly to the logging operation itself, and structural effects from the removal of merchantable material.” Activity effects to forest vegetation owing directly to the logging operation itself are described under section 4.1.2 Direct, Indirect, and Cumulative Effects Common to All Alternatives and activity effects to forest vegetation concerning the silvicultural prescription for harvesting and reforestation are described in section 4.2.1 Direct and Indirect Effects of Salvage Harvest, Reforestation, and Roadside Hazard Treatments Common to All Action Alternatives.

The removal of dead trees through salvage logging has been documented in published literature, syntheses, and advocacy papers to have adverse long term effects on residual forest structure by removing the “biological legacy” component and subsequent recruitment necessary for habitat and ecosystem diversity (McIver and Starr 2001; Beschta 1995, Franklin and Agee 2003; Beschta et al. 2004; Karr et al. 2004; Lindemayer et al. 2004; DeLasalla et al 2004; DeLasalla et al 2006; Hutto 2006; Lindenmayer and Noss 2006; Reeves et al. 2006; Noss et al 2006). Such biological legacies include standing snags (both large and small), live fire-injured trees, and large down woody debris that serve as important components to habitat and ecosystem structure. However, "biological legacies differ by orders of magnitude in natural forests" (Franklin et al. 2003), and consequently, treatment effects on biological legacy components should be reconciled with scale and context of site specificity. As noted in Franklin and Agee (2003): "uncharacteristic stand-replacement fires in dry forests can produce uncharacteristic levels of post-fire fuels, including standing dead and down trees" and suggest that "removing portions of that particular biological legacy may be appropriate part of an intelligent ecological restoration program and not simply salvage."

While some of the literature, syntheses, and opinion papers advocate no salvage and/or replanting, others recognize that some salvage and/or replanting may be appropriate given context and intensity of the fire disturbance relative to the natural fire regime (i.e. "uncharacteristic stand-replacing fires in dry forests"), land allocations, and management objectives. For example, Everett (1995), McIver and Starr (2001), Franklin and Agee (2003), Lindenmayer and Noss (2006), Reeves et al (2006), and Peterson et al (2009) all acknowledge that, while such practices may have negative effects, these treatments may be appropriate given either objectives, site specific analysis, and appropriate mitigations to protect for values such as maintaining components of biological legacies. The design of action alternatives address the potential for negative effects and provide incorporated design criteria, standard management requirements, and best management practices to reduce the potential for negative effects. Furthermore, all action alternatives are consistent with direction and land management objectives as described in the Plumas National Forest LRMP (1988) as amended by the 2004 SNFPA ROD.

All action alternatives are designed to *exclude* harvest activities (including other hazard tree removal and fire salvage projects) entirely from 73 percent (under alternative A) to 88 percent (under alternative E) of public lands within the analysis area and would only treat 11 (under alternative E) to 35 percent (under alternative A) of the public lands that burned with high severity (table 4.11). Consequently, large areas of unsalvaged and untreated areas would exist under all action alternatives maintaining forest stand structure that would provide for biological legacy values as described by Lindenmayer and Noss (2006). In addition, snag retention areas within salvage harvest units and exclusion of salvage harvest from low to moderate burn severity patches would provide for biological legacies within and outside the proposed treatment perimeters such as fire-killed and fire-injuredd trees and large live and dead trees that have high habitat value (Lindenmayer and Noss 2006). Equipment restriction zones (in units where ground-based logging is proposed) and snag retention guidelines within RHCAs are designed to provide for protection of aquatic ecosystems and retain and recruit structure such as large down woody debris within riparian areas (Lindenmayer and Noss 2006; Reeves et al. 2006).

Over time, the action alternatives (A, C, and D), would result in relatively lower surface fuel loads, potential flame lengths, and potential mortality. Fuel loadings and potential flame lengths would be lowest in ground-based salvage harvest units where the removal of submerchantable material (via biomass harvesting and removal or site preparation) would occur. While the potential for mortality will remain high in treated areas (greater than 80 percent of basal area), it would remain lower than that of the no action alternative for wildfires occurring under 90th percentile weather conditions. Potential future fires are expected to kill natural regeneration, planted conifers, brush, and residual larger trees. Overall, the action alternatives would result in minor reductions of future flame lengths and fire severity when compared with the no action alternative.

Effects of Post-Fire Treatments on Public Lands

All completed, current, and proposed post-fire treatments on public land other than what is proposed in the Moonlight and Wheeler Fires Recovery and Restoration Project can be found in Appendix B of the Environmental Impact Statement. Table 4.11 below displays the percent of acres affected by post-fire harvesting treatments on public land by fire severity within the analysis area. The percentage includes all post-fire harvest treatments within this project as well as those completed or proposed on other districts or forests.

Table 4.11 Comparison of alternatives: Percent of acres affected by the completed, current, and proposed post-fire harvesting treatments on public land within the analysis area for all alternatives.

		Low Severity	Moderate Severity		High Severity	Total for all severity classes
		BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total Acres of Public Lands within Analysis Area		13600	6983	6531	41294	68408
Percent of Analysis Area		20%	10%	10%	60%	100%
Alternative A	Percent of Acres Affected by Post-Fire Harvest Treatments on Public Lands	**14%**	**13%**	**17%**	**35%**	**27%**
Alternative B	Percent of Acres Affected by Post-Fire Harvest Treatments on Public Lands	**7%**	**6%**	**7%**	**5%**	**5%**
Alternative C	Percent of Acres Affected by Post-Fire Harvest Treatments on Pubic Lands	**14%**	**12%**	**14%**	**21%**	**18%**
Alternative D	Percent of Acres Affected by Post-Fire Harvest Treatments on Public Lands	**14%**	**12%**	**13%**	**14%**	**14%**
Alternative E	Percent of Acres Affected by Post-Fire Harvest Treatments on Public Lands	**14%**	**12%**	**13%**	**11%**	**12%**

Alternative A would have the largest effect, affecting 27 percent of public lands within the analysis area. Alternative B would have the least effect with only 5 percent of the public lands in the analysis area being affected. Of the action alternatives, alternative E would have the least effect with 12 percent of public lands within the analysis area being affected.

Table 4.12 below displays the percent of public land acreage in the analysis area that would be affected by post-fire reforestation treatments. Direct, indirect, and cumulative effects of reforestation are discussed in detail in Section 4.2.

Reforestation activities would have a positive long-term effect on vegetation types, by promoting re-establishment of conifer CWHR vegetation types (Sierra Mixed Conifer Size Class 1) across areas that would otherwise remain as non-forest vegetation types (Montane Chaparral) much longer otherwise.

Table 4.12 Comparison of alternatives: Percent of acres affected by the completed, current, and proposed post-fire reforestation treatments on public land within the analysis area under all alternatives.

		Low Severity	Moderate Severity		High Severity	Total for all severity classes
		BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total Acres of Public Lands within Analysis Area		13600	6983	6531	41294	68408
Percent of Analysis Area		20%	10%	10%	60%	100%
Alternative A	Percent of Acres Affected by Post-Fire Reforestation Treatments on Public Lands	**7%**	**8%**	**24%**	**52%**	**36%**
Alternative B	Percent of Acres Affected by Post-Fire Reforestation Treatments on Public Lands	**0%**	**0%**	**13%**	**18%**	**12%**
Alternative C	Percent of Acres Affected by Post-Fire Reforestation Treatments on Pubic Lands	**7%**	**7%**	**20%**	**37%**	**25%**
Alternative D	Percent of Acres Affected by Post-Fire Reforestation Treatments on Public Lands	**7%**	**8%**	**24%**	**52%**	**36%**
Alternative E	Percent of Acres Affected by Post-Fire Reforestation Treatments on Public Lands	**7%**	**8%**	**24%**	**52%**	**36%**

Alternatives A, D, and E proposes to reforest 36 percent of the public lands within the analysis area (52 percent of public lands that burnt under high severity). This acreage includes all proposed reforestation from the Moonlight and Wheeler Fires Recovery and Reforestation Project plus all other projects on public land within the analysis area. Alternative B (no action) would reforest 12 percent of public lands (18 percent that burned at high severity). Of the action alternatives, alternative C proposed to reforest the least amount of acreage with 25 percent of all public lands (37 percent that burned at high severity).

Cumulative Effects of Completed, Current, and Proposed Post-Fire Treatments

Tables 4.13 below compares all alternatives by percentage of acres cumulatively affected by completed, current, and proposed post-fire harvesting treatments within the analysis area. The percentage shown is the proportion of acres cumulatively affected for all post-fire harvest activities within the analysis area by alternative and fire severity. Refer to Sections 4.1.3 and 4.2.2 below for individual cumulative effect analysis for post-fire harvest activities by alternative.

Table 4.13 Comparison of alternatives: Percent of acres cumulatively affected by the completed, current, and proposed public and private post-fire harvesting treatments within the analysis area under all alternatives.

		Unclassified due to Satellite Imagery	Low Severity	Moderate Severity		High Severity	Total for all severity classes
			BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total Acres within Analysis Area		258	16679	8401	7770	54539	87647
Percent of Analysis Area		0.3%	19%	10%	9%	62%	100%
Alternative A	Percent of Acres Cumulatively Affected by Post-Fire Harvest Treatments	**0%**	**20%**	**19%**	**22%**	**44%**	**35%**
Alternative B	Percent of Acres Cumulatively Affected by Post-Fire Harvest Treatments	**0%**	**14%**	**14%**	**14%**	**20%**	**18%**
Alternative C	Percent of Acres Cumulatively Affected by Post-Fire Harvest Treatments	**0%**	**20%**	**19%**	**20%**	**33%**	**28%**
Alternative D	Percent of Acres Cumulatively Affected by Post-Fire Harvest Treatments	**0%**	**20%**	**19%**	**20%**	**27%**	**24%**
Alternative E	Percent of Acres Cumulatively Affected by Post-Fire Harvest Treatments	**0%**	**20%**	**19%**	**20%**	**25%**	**23%**

Table 4.13 displays the range of alternatives for the Moonlight and Wheeler Fires Recovery and Restoration Project for all harvest activities. The percentages above include the affected acreage for all post-fire harvest treatments proposed for the Moonlight and Wheeler Fires Recovery and Restoration Project, all other post-fire harvest treatments on public lands, and all post-fire harvest treatments on private lands (Appendix B).

Cumulatively, alternative A would have the most effect, affecting just over one-third (35 percent) of all lands within the analysis area while alternative B (no action) would have the least, affecting 18 percent cumulatively over the analysis area. Of the action alternatives, alternative E would have the least cumulative effect with 23 percent of all lands affected by post-fire harvest activities.

Table 4.14 below compares all alternatives by percentage of acres affected by completed, current, and proposed post-fire reforestation treatments within the analysis area. This table is displayed in the same format as table 32 where the percentage shown is the proportion of acres cumulatively affected for all post-fire reforestation treatments within the analysis area by alternative and fire severity. Again, refer to Sections 4.1.3 and 4.2.2 below for individual cumulative effects analysis for post-fire reforestation treatments by alternative.

Table 4.14. Comparison of alternatives: Percent of acres cumulatively affected by the completed, current, and proposed post-fire reforestation treatments within the analysis area under all alternatives.

		Unclassified due to Satellite Imagery	Low Severity	Moderate Severity		High Severity	Total for all severity classes
			BA Mortality 0-25%	BA Mortality 25-50%	BA Mortality 50-75%	BA Mortality 75-100%	
Total Acres within Analysis Area		258	16679	8401	7770	54539	87647
Percent of Analysis Area		0.3%	19%	10%	9%	62%	100%
Alternative A	Percent of Acres Cumulatively Affected by Post-Fire Reforestation Treatments	**0%**	**14%**	**15%**	**29%**	**56%**	**42%**
Alternative B	Percent of Acres Cumulatively Affected by Post-Fire Reforestation Treatments	**0%**	**8%**	**8%**	**19%**	**31%**	**23%**
Alternative C	Percent of Acres Cumulatively Affected by Post-Fire Reforestation Treatments	**0%**	**14%**	**14%**	**26%**	**44%**	**34%**
Alternative D	Percent of Acres Cumulatively Affected by Post-Fire Reforestation Treatments	**0%**	**14%**	**15%**	**29%**	**56%**	**42%**
Alternative E	Percent of Acres Cumulatively Affected by Post-Fire Reforestation Treatments	**0%**	**14%**	**15%**	**29%**	**56%**	**42%**

Table 4.14 displays the range of alternatives for the Moonlight and Wheeler Fires Recovery and Restoration Project for all post-fire reforestation treatments. The percentages above include the affected acreage for all post-fire reforestation treatments proposed for the Moonlight and Wheeler Fires Recovery and Restoration Project, all other post-fire reforestation treatments on public lands, and all post-fire reforestation treatments on private lands.

Cumulatively, alternatives A, D, and E would have the most effect, affecting 42 percent of all lands within the analysis area. Alternative B would have the least effect with 23 percent of all lands being affected by post-fire reforestation treatments. Of the action alternatives, alternative C would have the least effect with 34 percent of all lands being affected by post-fire reforestation treatments.

Alternative A. These cumulative effects would be most realized under alternative A (the proposed action) due to the greater number of acres proposed for salvage harvesting utilizing helicopter and skyline harvest systems. Table 4.13 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire harvest treatments under alternative A. Approximately 35 percent of the acres within the analysis area would be cumulatively affected by these projects. These are primarily areas that burned with moderate to high severity, and would experience reduced numbers of snags and large woody debris recruitment. Conversely, approximately 65 percent of the analysis area would not be affected by any post-fire projects and would continue to develop as described under the no action alternative.

Table 4.14 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire reforestation treatments under alternative A.

Under alternative A, approximately 42 percent of all lands within the analysis area, (56 percent of all lands which burned with high fire severity), would be reforested. Recent studies (Stephens & Moghaddas 2005; Thompson et al. 2007) have found an “association of high-severity fire with conifer plantations” and suggests that “young forests, whether naturally or artificially regenerated, may be vulnerable to positive feedback cycles of high severity fire creating more early-successional vegetation and delaying or precluding the return of historical mature-forest composition and structure” (Thompson et al. 2007). Reforestation treatments under action alternatives are designed in acknowledgement of these findings to promote lower density open canopy plantations in order to reduce susceptibility of reforested areas to potential high severity fires. In addition, these studies suggest that young post-fire vegetation, whether naturally or artificially regenerated, is at high risk to high severity reburns, particularly in the early stages of forest development, and managers may have few options in these early successional forest types for reducing the risk of high severity.

Trees planted utilizing the wide-spaced cluster arrangement are expected to have a lower likelihood of propagating a high severity crown fire under 90th percentile weather conditions as their live crowns would be well separated. One to two years following planting, a manual release would occur around the clusters to reduce competition with grasses and brush and enhance tree survival and growth. This reduction of fine shrub, grass, and associated surface fuels around the planted clusters would break up the continuity of shrub and surface fuels, and would contribute to a reduction in flame lengths and rates of spread in the immediate vicinity of planted trees, leading to decreased potential for torching of individual trees.

Reforestation treatments would cumulatively affect 42 percent of all lands within the Moonlight and Antelope Complex fires (56 percent of all lands that burned with high severity). This is the equivalent of reforesting approximately 48 square miles of land that burned with high fire severity while leaving approximately 37 square miles untreated and reliant on natural regeneration processes to re-establish forested conditions. Reforestation activities would have a positive long-term effect on vegetation types, by promoting re-establishment of conifer CWHR vegetation types (Sierra Mixed Conifer Size Class 1) across areas that would otherwise remain as non-forest vegetation types (Montane Chaparral) much longer otherwise.

Alternative C. Under alternative C, cumulative effects would be reduced in scale proportionate to the reduced number of acres of salvage harvest and reforestation proposed alternative C. Table 4.13 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire harvest treatments under alternative C. Cumulatively, 28 percent of the acres within the analysis area would be affected by these projects. These areas are primarily areas that burned with moderate to high severity, and would experience reduced numbers of snags and large woody debris recruitment. Conversely, approximately 72 percent of the analysis area would not be affected by any post-fire harvest projects and would continue to develop as described under the no action alternative.

Table 4.14 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire reforestation treatments under alternative C. Potential for high reburn severity would exist as described under cumulative effects for alternative A.

Under alternative C, approximately 34 percent of all lands within the analysis area, (44 percent of all lands which burned with high fire severity), would be reforested. This is the equivalent of reforesting approximately 37 square miles of all lands within the analysis area that burned with high fire severity while leaving approximately 48 square miles untreated and reliant on natural regeneration processes to re-establish forested conditions.

Alternative D. Under Alternative D, cumulative effects would be reduced by the number of acres proposed under Alternative D. Alternative D is 2001 Sierra Nevada Framework Plan consistent and avoids Old Forest Emphasis areas and California spotted owl protected activity centers except where they intersect the roadside corridor.

Table 4.13 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire harvest treatments under Alternative D. Cumulatively, 24 percent of the acres within the analysis area would be affected by these projects. These areas are primarily areas that burned with moderate to high severity and would experience reduced numbers of snags and large woody debris recruitment. Conversely, 76 percent of the analysis area would not be affected by any post-fire harvest projects and would continue to develop as described under the no action alternative.

Table 4.14 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire reforestation treatments under Alternative D. Potential for high reburn severity would exist as described under cumulative effects for Alternative A.

Alternative D includes reforestation on salvage harvest units treated under Alternative D plus the footprint of Alternative A. As a result, the same amount of acres will be reforested in Alterative D as in Alternative A. Under alternative D, approximately 42 percent of all lands within the analysis area, (56 percent of all lands which burned with high fire severity), would be reforested. This is the equivalent of reforesting approximately 48 square miles of all lands that burned with high fire severity while leaving approximately 37 square miles untreated and reliant on natural regeneration processes to re-establish forested conditions.

Alternative E. All action alternatives include the removal of roadside hazard trees. Alternative E represents roadside hazard tree removal and reforestation only while in Alternatives A, C, and D, the roadside hazard tree removal supplements salvage harvest and reforestation.

Cumulative effects for the roadside hazard tree removal portion of this project rely on current environmental conditions as a proxy for the impacts of past actions. This is because existing conditions reflect aggregate impacts of all prior human actions and natural events that have affected the environment and might contribute to cumulative effects. Current and proposed fire recovery projects on both public and private lands are considered within the analysis area.

These effects are substantiated by past similar post-fire roadside hazard tree removal projects that have occurred on the Mt. Hough Ranger District. Roadside hazard tree removal projects on the Mt Hough Complex (1999), Storrie fire (2000), Stream fire (2001), and Antelope Complex (2007) were proposed and implemented to provide public safety along forest roads. Some of these similar projects overlapped with additional salvage proposals that were implemented such as the roadside hazard tree removal project that occurred within the Stream fire, while others did not (roadside hazard tree removal projects associated with the Mt. Hough Complex and Storrie fire. In either case, these projects displayed similar limited and dispersed effects that were minimal in scale and did not substantially affect forest vegetation on either the stand or landscape level.

Where the roadside hazard portion of this project may overlap with future projects, subsequent projects would be designed to meet snag retention guidelines as specified in the Plumas National Forest LRMP (1988) as amended by the HFQLG Forest Recovery Act (1999) and the Sierra Nevada Framework Plan Amendment (2004). This, in addition to the areas that will remain untreated, will allow for burned forest habitat and snag and large down woody debris components to be maintained where there is little safety hazard posed to the public. Snag retention and recruitment of large down woody debris would continue within these areas.

Table 4.13 displays the percent fire severity acres affected by the completed, proposed, and current post-fire harvest treatments under Alternative E. Cumulatively, 23 percent of the acres within the analysis area would be affected by these projects. These are areas along traveled Forest Service roadways, and these areas would experience reduced numbers of snags and large woody debris recruitment. Conversely, approximately 77 percent of the analysis area would not be affected by any post-fire harvest projects and would continue to develop as described under the no action alternative.

Table 4.14 displays the percent of fire severity acres affected by the completed, proposed, and current post-fire reforestation treatments under Alternative E. Potential for high reburn severity would exist as described under cumulative effects for Alternative A.

Under alternative E, approximately 42 percent of all lands within the analysis area, (56 percent of all lands which burned with high fire severity), would be reforested. This is the equivalent of reforesting approximately 48 square miles of all lands that burned with high fire severity while leaving approximately 37 square miles untreated and reliant on natural regeneration processes to re-establish forested conditions.

5. Additional Analysis Summary for Response to Comments

5.1.1 Effects of Post-fire logging of fire-killed trees in high serverity areas

The direct effect of harvesting fire-killed trees under the action alternatives are displayed in tables 4.6 and 4.7 by treatment. In addition, the cumulative effects of post-fire timber projects are discussed in the cumulative effects section for all alternatives and action alternatives. However, the action alternatives under the Moonlight and Wheeler Fires Recovery and Restoration Project provide for snag retention within RHCA’s and within snag retention areas that would be excluded from harvest. In addition, the action alternatives were designed to maintain areas where no post-fire harvesting activities would occur; approximately 73 percent of the public lands within these fires would not be treated under alternative A and approximately 88 percent of public lands within these fires would not be treated under alternative E (table 4.3a). Consequently, at least 49,000 acres of public land (over 26,000 of which burned with high severity), would maintain existing snags across the landscape.

5.1.2 Effects of post-fire logging on changes in diversity of fire effects (low, moderate, and high fire severity) across the landscape

Table 4.13 display the cumulative effects of post-fire logging projects by fire severity within the analysis area. Treatments proposed under action alternatives for the Moonlight and Wheeler Fires Recovery and Restoration Project primarily target areas that burned with high vegetation severity; however, when considered cumulatively with other post fire projects within the analysis area, the diversity of fire effects (as represented by fire severity) is maintained on public lands.

5.1.3 Effects of post-fire logging on recruitment of large woody debris

Project design as described above under 'Effects of Post-fire logging of fire-killed trees in high severity areas' describes the large areas of public land within the analysis area where large woody debris would be maintained and recruited. It should be noted that reductions of large woody debris are directly related to effects of the wildfire where much of the pre-existing downed woody debris was completely or partially consumed. Salvage harvesting treatments would not remove existing down woody debris, and would likely contribute to large woody debris in the short-term by leaving cull log material within the units.

Treatments in action alternatives A, C, and D include snag retention areas and snag recruitment within RHCAs both of which retain snags that would serve as recruitment for large woody debris (tables 4.1, 4.6, and 4.7). Within RHCAs, generally four to six of the largest snags per acre would be retained, preferably within falling distance of the channel where available, to provide for large down woody debris recruitment to best meet riparian management objectives. Within ground-based salvage harvesting treatments, snag retention in RHCAs would be most preferable and efficient within equipment exclusion zones where snags would be within reasonable falling distance of the channel for large woody debris recruitment and harvesting safety issues would be minimized due to equipment exclusion.

Average tons per acre of large woody debris (as represented by surface fuels greater than 12 inches in diameter) within snag retention areas and untreated areas (as represented under the no action alternative) and treated areas (including RHCAs), are shown in tables 4.2 and 4.9, respectively and summarized in table 5.1.

Table 5.1. Measures for large woody debris amounts and recruitment

	Alternative A	Alternative B	Alternative C & D	Alternative E
Avg. Tons/Ac of Large woody debris (short-term: Post-harvest)	within treated areas: 1.1 - 4.3 within snag retention areas: 0.5	All areas: 0.5	within treated areas: 1.1 – 1.3 within snag retention areas: 0.5	with in treated areas: 1.1 – 1.3 All other areas: 0.5
Avg. Tons/Ac of Large woody debris (long-term: 30 years)	within treated areas: 0.8 – 10.8 within snag retention areas: 12.4	All areas: 12.4	within treated areas: 0.8 – 4.4 within snag retention areas: 12.4	within treated areas: 0.8 – 4.4 All other areas: 12.4
Avg. number of snags > 15" available for large woody debris recruitment to streams (Short-term: Post-harvest)	4 - 6 snags per acre in treated RHCAs	>15.6 snags per acre	4 – 6 snags per acre in treated RHCAs	>15.6 snags per acre

These values were used along with acres by treatment and pre-fire vegetation type to estimate a weighted average of large woody debris (greater than 12 inches) within the treatment units and project area as shown in table 5.2.

Table 5.2 Weighted average tons per acre of large woody debris (greater than 12 inches) in the short term (post-harvest) and the long term (30 years) within the treatment units and project area.

	Treatment Units		Project Area	
	Post Harvest	30 years	Post Harvest	30 years
Alternative A	1.5	5.3	1	6.4
Alternative B	--	--	0.6	9.3
Alternative C & D	1.1	2.8	0.7	7.4
Alternative E	1.1	2.8	0.6	9.3

As discussed above, the fires consumed much of the existing large woody debris throughout the project area. Salvage harvesting treatments would not remove existing down woody debris and, in the short-term, would likely contribute to large woody debris; however, in the long-term, action alternatives that remove dead trees would reduce recruitment of large woody debris.

It should also be noted that silvicultural guidelines specify harvest of dead trees only. Post-fire mortality of fire-injured trees, particularly within moderate and high fire severity areas, would occur in the first three to five years immediately following the fire event. Snag recruitment and large woody debris recruitment would continue to occur within untreated areas as well. Snag retention and recruitment and recruitment of large woody debris would occur the 73 to 88 percent of public lands which would not be subject to project proposals as detailed in table 4.11.

5.1.4 Effects of yarding and temporary road and landing construction

As described under section 4.2.1, construction of skid trails, landings, and temporary roads would require incidental removal of trees beyond those described for silvicultural purposes. This may include incidental removal of live trees for operability. However, the location and size of skid trails, landings, and temporary roads, and the trees harvested for the construction of such facilities must be approved and agreed upon by the Forest Service. Live tree removal would be permitted by necessity to facilitate such facilities, and would be avoided whenever practicable; it is estimated that removal of green trees would account for less than one percent of harvested trees. Therefore, the removal of trees for operability would be an incidental component of harvesting activities, of minimal size and scale, and highly dispersed, and would have negligible effects on stand structure.

5.1.5 Effects of post-fire logging and lop and scatter practices on natural regeneration, surface fuels and fire behavior

Post –fire logging activities may damage, kill or otherwise hinder natural regeneration, particularly in ground-based harvesting treatments. However, all harvest operations roads would adhere to the standards and guidelines set forth in the timber sale administration handbook (FSH 2409.15 including Region 5 supplements) and the Best Management Practices as delineated in the Water Quality Management for Forest System Lands in California: Best Management Practices (USDA 2000). In addition, the PNF LRMP (1988) soil quality guidelines provide direction that landings and permanent skid trails should not encompass more than 15 percent of timber stands. Consequently, mortality of natural regeneration due to crushing or compaction by equipment would be limited in size and scale to skid trails, and dispersed throughout the timber stand.

Based on information in tables 4.2 and 4.9 surface fuels loading in lop and scatter material (as represented by surface fuel loads) would not substantially increase in treated areas compared to the no action alternative. While an increase in fuel loading may cause an increase in fire behavior and potential severity, this would be a short-term effect and the total tons per acre would still be relatively low. While surface fuel loads in lop and scatter material may contribute to an increase in total flame length (under 90th percentile weather conditions) and predicted percent of basal area killed (under 90th percentile weather conditions) immediately post harvest, this effect is not substantially different from the no action alternative within 10 years post harvest due to natural breakage of limbs and tops and snag fall of dead trees. Lopping and scattering of limbs and tops may also bury or hinder natural regeneration under all alternatives including the no action alternative; however, this material may also provide ancillary benefits as “dead shade”, particularly for those species such as Douglas-fir and true fir types that prefer partial shading.

Table 5.3 Measures for surface fuel loadings and potential fire severity.

	Alternative A	Alternative B	Alternative C & D	Alternative E
Avg. Tons/Ac (Surface Fuel Load –post Harvest)	9.9 -13.0	9.1	9.9 - 10.4	9.1 – 10.4
Avg. Tons/Ac (Surface Fuel Load –10 years post Harvest)	9.1 - 20.0	19.0	9.1 – 14.9	9.1 – 19.0
Total Flame Length (ft) under 90th percentile weather conditions (Post harvest)	6.1	4.0	6.1	4.0 – 6.1
Total Flame Length (ft) under 90th percentile weather conditions (10 years)	6.3	7.7	6.3	6.3 – 7.7
Percent of basal area killed under 90th percentile weather conditions Post harvest)	88.9 %	58.3 %	88.9%	58.3% - 88.9%
Percent of basal area killed under 90th percentile weather conditions (10 years)	87.3 %	93.2 %	87.3 %	87.3% - 93.2%

Action alternatives would have a short-term increase of surface fuel loads immediately post harvest due to lop and scatter treatments. This short-term increase would be greatest in helicopter and skyline treatment units (approximately 13.0 tons per acre, representing a 42 percent increase) and substantially less in ground-based units (approximately 9.9 tons per acre, representing a 9 percent increase). However, within ten years, surface fuel loads under the action alternatives would be more varied and diverse ranging from substantially less than the no-action alternative (within ground-based units) to surface fuel loads that do not notably differ from the no-action alternative (within helicopter and skyline units). Due to these variable surface loads across the landscape, the action alternatives may create conditions which would promote a diversity of potential future fire effects versus the no action alternative where greater homogeneity of surface fuel loads would exist.

Alternative D is expected to be consistent with the post-logging fuel loading and predicted flame lengths for alternative C. Alternative E (roadside hazard tree removal only) is expected to more closely relate to effects shown under alternative B, although alternative E will result in slightly lower flame lengths and average tons per acre of fuel 10 years post harvest because of the roadside treatments and subsequent piling along the roadside. Alternative E is fairly small in scale (treating only 6 percent of the public lands within the analysis area) leaving the remaining 94 percent to exist as shown under alternative B above in table 5.3.

Under all action alternatives, treatment units would be reforested with a mixture of species native to the ecological stand type as described in 4.2.2 (Direct and Indirect Effects of Salvage Harvest and Reforestation for All Action Alternatives—Effects of Reforestation on Forest Vegetation) utilizing the wide-spaced cluster planting design. This cluster planting is designed to establish planted seedlings in order to meet desired stocking levels or desired species within acceptable temporal bounds while allowing for any natural regeneration that may occur. This would enhance re-establishment of forested conditions while allowing for and mimicking the heterogeneity and pattern of a naturally occurring forest.

5.1.6 Effects of reforestation on shrub habitat and future fire severity potential

Under all action alternatives, treatment units would be reforested with a mixture of species native to the ecological stand type as described in section 4.2.2 utilizing the wide-spaced cluster planting design. Clusters of three trees per cluster would be spaced 25-33 feet apart, resulting in a stocking of approximately 100-200 trees per acre. While reforestation activities would enhance the re-establishment of open canopy forested conditions, it is reasonably expected that these plantations would continue to have notable shrub components, particularly in the first twenty to thirty years of growth.

Typical high density plantations (300 to 400 trees per acre planted 10 to 12 feet apart) that have close spacing would burn under high severity (Stephens and Moghaddas 2005b;

Thompson et al. 2007) and this is acknowledged. High density plantations would not be established under any action alternatives, though variable density stands of naturally regenerated conifers would likely occur on sites favorable for natural regeneration and would also be susceptible to burning under high severity (Thompson et al. 2007)

Trees planted utilizing the wide-spaced cluster arrangement are expected have a lower likelihood of propagating a high severity crown fire under 90th percentile weather conditions as their live crowns would be well separated. One to two years following planting, a manual release would occur around the clusters to reduce competition with grasses and brush and enhance tree survival and growth. This reduction of fine shrub, grass, and associated surface fuels around the planted clusters would break up the continuity of shrub and surface fuels, and would contribute to a reduction in flame lengths and rates of spread in the immediate vicinity of planted trees, leading to decreased potential for torching of individual trees.

Finally, the total cumulative reforestation activities would be approximately 34 (under alternative C) to 42 percent (under alternatives A, D, and E) of all lands that burned in the Moonlight and Antelope Complex fires and 44 (under alternative C) to 56 (under alternatives A, D, and E) percent of the public lands within the Moonlight and Antelope Complex fire areas that burned under high fire severity (table 4.14). The relative size and distribution of the planted areas compared to the total area would greatly limit spread of fire between planted areas. In addition, the remaining public lands within the Moonlight and Antelope Complex fires area that burned would be available to grow into shrub habitat without any reforestation activities. Table 5.4 below summarizes the potential effects of shrub habitiat and future fire severity by alternative.

Table 5.4 Measures for shrub habitat and future potential fire severity

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Acres proposed for reforestation	16006	0	9306	16006	16006
Percent of public lands reforested (cumulative)	36 %	12 %	25 %	36 %	36 %
Avg. Tons/Ac of Surface fuels (30 years)	7.5 – 25.0	29.5	7.5 – 13.8	7.5 – 13.8	7.5 – 29.5
Total Flame Length (ft) under 90th percentile weather conditions (30 years)	6.9	10.9	6.9	6.9	6.9 – 10.9
Percent of basal area killed under 90th percentile weather conditions (30 years)	84.7 %	94.3 %	84.7 %	84.7 %	84.7% - 94.3%

The combination of the proportion to be planted, the previously mentioned wide tree spacing and manual grubbing of vegetation, would result open canopied forested stands with an overall lower likelihood of a high severity crown fire initiating in or moving through the planted stands. It is expected that due to the small size of both naturally regenerated and planted trees, wildfire under 90th percentile and above conditions would result in high mortality of these trees as well as shrubs. While the risk of potential high severity fire in the future is real, this risk should not be warranted rational to forgo reforesting burned areas and promoting the re-establishment of previously forested conditions on public lands as described in NFMA (1976). In addition, future high severity fire would likely perpetuate shrub habitat as discussed in Thompson et al. (2007) and as described in Nagel and Taylor (2005).

Manual grubbing and/or removal of competing vegetation down to mineral soil about five feet in diameter would occur around the planting site to enhance survival and growth of planted seedlings. Assuming 100 to 200 trees per acre would be planted and grubbing would occur around these planted seedlings, manual removal of grasses, forbs and shrubs could occur on 18 to 36 percent of each planted acre. This effect is expected to be negligible as grass, forb, and shrub vegetation would remain on 64 to 82 percent of each planted acre. In addition, the effect of grubbing would be short-lived as vegetation re-colonizes the grubbed area. However, the long-term beneficial effects of these treatments include enhanced survival and growth of planted tree seedlings.

5.1.7 Effects of burning and post-fire logging on air quality and dust production

Under alternatives A, C, D, and E pile burning would be concentrated in helicopter and/or tractor harvest landings and along the roadside cooridor. Due to the dispersed nature of the burn piles, the near complete combustion of piled material, and the control over ignition times to favor good smoke dispersion, it is not anticipated that pile burning would substantially impact the local communities. Smoke would be blown to the northeast towards Susanville and Janesville by typically southwest winds during the day. At night, smoke from burn piles in the project area would move down the Indian Creek drainage towards the community of Genesee Valley or down Moonlight and Lights Creek towards North Arm/Indian Valley. All burning would be completed under approved burn and smoke management plans. Piles would be constructed to minimize mixing of soil and burned under weather conditions that would allow efficient combustion. Particulate matter generated by alternative is shown in table 4.10 and summarized below in table 5.5. Predicted emissions from smoke production would be spread out over a period of three to five years depending on the implementation timelines of salvage harvest and roadside hazard removal treatments and the occurrence of favorable burning conditions.

Table 5.5 Measures for smoke production and air quality.

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Particulate Matter 10 (tons)	324	0	218	169	147
Particulate Matter 2.5 (tons)	292	0	196	152	132
Total Vehicle Dust Emmissions (tons)	567	0	328	217	169

Dust emissions (table 4.10 and table 5.5) would be spread out during the mechanical treatment implementation period of approximately three to five years. Dust would be mitigated by road watering and other standard management practices described in contracts (sections T-806 and B-5.3). No known serpentine based soils are in the project area that would be disturbed by project implementation activities. Alternative E would have the lowest overall dust emissions when compared to action alternative A.

5.1.8 Snagfall Rates

The Wilson memo (1999) which propose modeling snag fall rates for trees between 24 and 40 inches DBH at a half life of 32 years (indicating that 50 percent of snags in that size class will have fallen within 32 years after mortality), appears to be modeling the snag fall of "natural" background tree mortality (i.e.: not fire-killed mortality). Effects of snag fall displayed in the analysis was based on a combination of 1)past experience of snag fall in the Will fire (1979) and the Elephant fire (1982) (Rotta 2008, pers. comm.), 2) Forest Vegetation Simulator modeling, and 3) relevant scientific literature. Observations from past fires are relevant because 1) they are local past fires within reasonable proximity to the project area and 2) literature (Chambers and Mast 2005) suggests that fire-killed trees tend to fall at faster rates. In addition, the snag fall rates are generally consistent with the applicable literature concerning fire-killed snags, of course considering locality and limitations of each particular study: Russell et al. (2006); Chambers and Mast (2005); Dahms (1949); as well as Passovoy and Fule (2007), who found that "few fire-created snags remained by the 27th year post-fire." Snag fall rates of "natural" mortality trees would not be applicable because 1) the event causing the mortality is different, and 2) the density of the surrounding live trees may protect the snag from abiotic agents such as wind, whereas in a fire-killed scenario, most surrounding trees are likely also dead and would provide little to no protection.

While small snags may fall faster than larger snags, this may be difficult to predict particularly when such trees may pose a hazard to public safety. Snag fall can be compounded by structural defects, site conditions such as slope and soil properties, as well as biotic elements such as wind. This proved to be true in the Spring of 2009 when additional, both large and small snags fell onto the travel routes within the project area. Lastly, trees may fail entirely or in part; while snag fall rates usually focus on the entire stem of the tree; parts such as limbs, tops, and logs may fail sooner than timeframes described under the literature for snag fall rates. Hazard tree removal guidelines must also recognize that failing limbs and tops have the capacity represent a hazard as does the entire tree.

5.1.9 Roadside Hazard Tree Removal Marking Guidelines

The Plumas National Forest Roadside /Facility Hazard Tree Abatement Action Plan (2008) and corresponding removal guidelines provides direction on hazard tree identification and abatement. It is reasonably anticipated that tree mortality associated with fire-injury may occur for years subsequent to the Moonlight Fire. Fire-injured tree marking guidelines for this project were developed by the Pacific Southwest Region Forest Health Protection Staff, based upon tree mortality models from the latest scientific research by Fire Sciences Laboratory at the Rocky Mountain Research Station (Hood et al. 2007) and Pacific Southwest Region Forest Health Protection Staff. These guidelines are based on tree data collected on over 5,000 trees, which is the largest database available of fire-injured trees in California. These marking guidelines incorporate 4 year post-fire data from Smith and Cluck (2007), as well as research from “Predicting post fire mortality of seven western conifers (Ryan and Reinhardt, 1988), and field examination and recommendations by Danny Cluck, Forest Health Protection staff entomologist (July 27, 2007).

Identification and designation of hazard trees is consistent with and follows the Plumas National Forest Roadside/Facility Hazard Tree Abatement Action Plan (2008). The cambium sampling and stratified random sampling methods used in the study (Hood et al 2007) is consistent with scientific literature on monitoring fire-injured trees and ensures that data were collected from a wide range of tree injuries and sizes.

Comments regarding the roadside hazard tree removal treatments were addressed in the Moonlight Roadside Hazard Tree Removal Project Record, as well as the declarations (Tompkins 2008). In addition, a Forest Health and Protection Evaluation was performed to examine issues submitted by Dr. Chad Hanson in his declaration opposing the Moonlight Safety and Roadside Hazard Tree Removal Project (Case 2:08-cv-01957-FCD-EFB, September 15, 2008). For further information, please refer to Cluck 2009.

Hazard tree marking guidelines as described in the Environmental Impact Statement for the Moonlight and Wheeler Fires Recovery and Restoration Project were fully utilized by field crews in making their hazard determinations for individual trees.

When any specific marking criteria are applied in the field it is expected that there will be some level of variability in the assessment of individual trees among tree marking crew members. The scale of this type of project does not allow for detailed and time consuming measurements of each variable when making a fire-injured and/or hazard tree determination. (The Moonlight Safety and Roadside Hazard Tree Removal Project covered 4,389 acres; within this area approximately 57,666 trees were designated for removal out of over 320,400 total trees assessed). Marking crews are expected to make a rapid assessment, with a high level of accuracy, for each individual tree and move on. Therefore, it should be expected that some trees will be marked for removal, fully attempting to meet the intent of the guidelines, which may not meet the given criteria. The opposite is also true; trees that may meet the given criteria will not be marked for removal. Trees that fell into this second category were also observed and documented during this site visit. Out of the approximately 320,400 trees assessed by the marking crews in the Moonlight Safety and Roadside Hazard Tree Removal Project, approximately 68 percent were within high severity areas (characterized by 75 – 100 % basal area mortality) with the majority of trees marked for removal being completely dead (no green needles). This made the determination of hazard trees relatively simple with little potential for significant errors. Furthermore, based on the majority of trees observed along the 8.4 miles of road being dead (no green needles); thousands of roadside hazard trees were designated correctly. Based on the observations and information provided above, it appears that the number of trees that may have been incorrectly assessed as hazards (or non-hazards), is likely very low.

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